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Sanitation Manual for Public Ground Water Supplies

[This Manual is not an official document, but is one recommended by the U.S. P.H.S. for adoption by the states or their political subdivisions or administrative agencies. See page 534 for memorandum of transmittal.]

Section 1—Definitions

1. *Public water supply.* A public water supply is one from which water may be distributed, sold, or made available to the people at large or to any considerable number of members of the public indiscriminately.

2. *Public ground water supply.* A public ground water supply is a public water supply which obtains water from subsurface sources.

3. *Bottled water.* Bottled water means any water distributed, sold, or made available to consumers in bottles or other containers.

4. *Health officer.* Health officer means the health officer of any State, municipality, or district which adopts these requirements, or his duly authorized representative.

5. *Person.* Person means an individual, a partnership, a public or private corporation, an association, a joint stock company, a trust, or an estate.

6. *Cross-connection.* Any physical connection whereby the approved supply is connected with any other water supply system whether public or private, either inside or outside of any building or buildings in such manner that a flow of water into the approved water supply is possible either through the manipulation of valves or because of ineffective check or back pressure valves, or because of any other arrangement.

7. *Backflow connection.* Any system of piping or other arrangement whereby the public water supply is connected directly with a sewer drain, conduit, pool, storage reservoir, or other device which does or may contain sewage or other waste or liquid which would be capable of imparting contamination to the approved water supply.

8. *Auxiliary intake.* Any piping connection or other device whereby water may be secured from a source other than that normally used.

9. *Bypass.* Any system of piping or other arrangement whereby the water

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may be diverted around any part or portion of a water purification plant.

Section 2—Registration and Permits

From and after the date of adoption and publication of requirements for public ground water supplies by a state, municipality, or district, no person shall begin construction, alteration, or extension of any public ground water supply without first securing a written permit from the state health officer. Such permit shall be granted by the state health officer only after examination and approval of detailed plans and specifications which shall have been submitted by said person, or after such survey of the site or installation as the state health officer may deem necessary.

Not later than 6 mo. after the adoption and publication of requirements for public ground water supplies by a state, municipality, or district, all persons who own or control any public ground water supply shall submit to the health officer a report giving such information relative to said water supply as may be required by the health officer.

Section 3—Inspections

At least once during each 12-mo. period the health officer shall inspect all public ground water supplies in his jurisdiction for the purpose of ascertaining which supplies shall be termed "Approved Public Ground Water Supplies."

In case the health officer discovers any violation of the requirements which have been adopted, he shall require correction of such violations in writing specifying the corrections to be made and the time allowed for making them. A second inspection shall be made after the lapse of the time allowed for the defects to be remedied and the second inspection shall determine whether or not the supply shall be "approved."

Section 4—Emergency Measures to Prevent Epidemics

Whenever, in the opinion of the health officer, conditions arise in connection with any public ground water supply which warrant emergency measures to prevent a water-borne disease epidemic, said health officer is authorized to apply such measures as he may deem necessary.

Section 5—Approved Public Ground Water Supplies

All "Approved Public Ground Water Supplies" shall conform with the following items of sanitation:

Item 1—Exclusion of Surface Water from Site

The site of the source in all directions shall not be subject to flooding and shall be so graded and drained as to facilitate the rapid removal of surface water.

Public health reason—The exclusion of flood waters from the site and proper drainage of surface water away from the source will help to prevent contaminated surface water from reaching the source directly. If flood waters are excluded for a given horizontal distance, such waters may reach the source only by passage through the soil in the intervening distance, thereby providing a factor of safety against direct pollution.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) Pump platform, pump room floor, or cover of a ground water supply is not less than 2 ft. above the highest known high water level of any nearby body of surface water. Where necessary the area should be filled and graded to the necessary height and filling protected from erosion by rip rap.

(2) Flood waters from nearby bodies of surface water are not allowed to approach within less than 50 ft. of the source measured horizontally.

(3) The earth surfaces are sloped to drain away from or divert surface water around the spring, infiltration system, well, or pump house, and are so graded and maintained as to prevent the accumulation and retention of surface water within a distance of 50 ft. from the source in all directions.

(4) For hillside sites, an adequate intercepting ditch or ditches are constructed around the uphill side of the source in such manner and so maintained as to keep hillside storm water at least 50 ft. away from the source in all horizontal directions; the intercepting ditch or ditches may be protected against erosion by rip rap, concrete, or other equivalent ditch lining where necessary.

(5) The source is not located in a ravine where surface water flows may be obstructed or concentrated.

Item 2—Satisfactory Earth Formations Above the Water-Bearing Stratum

The earth formations above the water-bearing stratum shall be of such character and depth as to exclude contamination from the source. If satisfactory sites are not available the water shall be treated by a method or methods approved by the health officer for the specific installation.

Public health reason—The earth formations above the water-bearing stratum should be of such depth and character as to provide filtration sufficiently adequate to prevent contaminated surface water from reaching the source. Formations such as limestone, broken lava rock, coarse gravel, and brittle rocks whose interstices are in the form of channels, joints, and fissures provide little filtering action to prevent contamination from reaching the water-bearing stratum.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) The earth formations overlying the water-bearing stratum (natural or fill) consist of one or more impervious formations such as clay, silt, stiff clay mixtures, fine sand, or equivalent materials having a combined depth of not less than 10 ft.

(2) The backfill above an infiltration system consists of not less than 10 ft. of thoroughly compacted clay, silt, stiff clay mixtures, or equivalent materials.

(3) Treatment approved by the health officer is provided where satisfactory earth formations above the water-bearing stratum cannot be shown to exist. (Treatment may, of course, be required due to other unsatisfactory conditions even though satisfactory earth formations are known to exist).

Item 3—Distances to Sources of Contamination

Every public ground water supply and all appurtenances thereto shall be located at a safe distance from all sources of contamination such as pit

privies, cesspools, septic tanks, subsurface tile systems, sewers, drains, barnyards, and pits below the ground surface.

Public health reason—The organisms of typhoid fever, dysentery, and other enteric diseases are present in the body wastes of persons sick with these diseases or who are carriers of the diseases. If sources of contamination are located near the water supply source, disease organisms may reach the latter.

Ground waters located in formations such as limestone, broken lava rock, coarse gravel, brittle rocks, or equivalent materials which are not protected against the penetration of contamination by an adequate overlying impervious formation are not suitable for public ground water supplies without treatment.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) The distance from the water supply source to any means of contamination in all horizontal directions is not less than 50 ft. This minimum distance shall be used only where existing conditions indicate it to be sufficient; greater distances should be provided where local conditions indicate the need for greater protection.

(2) In case the area adjacent to the source is accessible to livestock, the site is completely surrounded by a fence located not less than 50 ft. from the source in all horizontal directions. Drainage from areas accessible to livestock in the vicinity of water sources is away from the water source.

* * *

MINIMUM DISTANCES TO SOURCES OF CONTAMINATION

Because of the many factors involved in the determination of a "safe distance" from sources of contamination, the following information is given for the guidance of those concerned:

Every ground water supply source such as a well, spring, or infiltration system, and all appurtenances thereto, should be located at a safe distance from any cesspool, privy, septic tank, and tile field, sewer, soil pipe or pipe through which sewage may back up, or from any other possible source of pollution, and in such manner as to prevent contamination of the water by either underground seepage or channels, or by surface drainage. Coarse gravel, limestone, disintegrated rock, or other porous material which will permit rapid flow of water through it are not suitable materials around a source of supply. When such formations are encountered, more suitable sites should be obtained. If satisfactory sites are not available, adequate treatment of the water should be provided.

The location of ground water supplies on a side hill or at the foot of a hill where cesspools, privies, sewers, or other sources of pollution are situated on the slope above and in the path of the ground water flow and within 300 ft. should be avoided.

When a body of ground water tapped by a well is drawn upon, the level of the water in the well will be lowered, and the surface of the ground water adjacent to the well will assume a form similar to an inverted cone. The amount which the water level is lowered decreases rapidly at increasing distances from the well, until at some point, more or less remote, there is no perceptible effect. The area within which the level is lowered appreciably is called the circle of influence.

Where the rate of pumpage from a well exceeds the percolation of water through the water-bearing formation, the water level in the well will drop and the circle of influence will be broadened. For a specific well the draw-down or drop in water level and the diameter of the circle of influence will be much greater usually when pumped at high rates than when pumped at low rates. Because of this fact, ordinary wells which are developed and equipped to provide large volumes of water are more likely to become contaminated from sources of pollution located at greater distances as compared to wells supplying small volumes of water. It is essential, therefore, that the minimum distances between the well and sources of contamination be increased as the rate of pumpage from the well is increased.

* * *

The Minnesota Department of Health has developed a formula for computing approxi-

mate safe distances between wells and sources of contamination based on the character of the soil, the capacity of the pump, the permissible velocity through the soil, the slope of the surface or water table, and the length of the screen or depth of flow toward the well. This formula, and tables computed by its application, are presented here:

Let D = Distance between well and the source of contamination, in feet.
P = Pump rate, in gallons per minute.
L = Length of well screen, depth of flow toward well, or thickness of water-bearing formation, in feet.
S = Angle of slope of ground in degrees (approximately parallel to the water table).
K = Coefficient of flow depending on character of soil.

For fine sand:
$K = 0.11$ gallons per square foot per minute.

For medium sand:
$K = 0.07$ gallons per square foot per minute.

For coarse sand and gravel:
$K = 0.03$ gallons per square foot per minute.

When the distance D is such that the limiting velocity K is not exceeded, then the total flow = pump effect plus slope effect.

$$2\pi DLK = P + 2\pi DL(K \text{ sine } S)$$

Solving for D.

$$D = \frac{P}{2\pi LK(1 - \text{sine } S)}$$

This formula is not accurate beyond the limits of accuracy of the data used in it. It should not be taken to give definite safe distances, but it has been found useful in checking judgment of distances in the preliminary study of well sites. Careful consideration must always be given to the geological formations on the site especially where there may be faults, ledges, or impermeable dams that interfere with the expected movement of the water.

This formula can be used to develop tables for checking existing installations or decisions regarding new sites. For those who have an aversion to working out a mathematical formula, the table would be helpful. Skeleton tables can be set up and the formula used to fill in any intermediate conditions. To illustrate the working of the formula and table, the following is presented:

TABLE 1

Pump capacity 500 gpm.—15-ft. screen

Character of soil	Degree of slope	Type of structure containing pollution: Cesspools, privies, and clay pipe sewers	Cast-iron pipe and metal tanks	Sewer connections with extra-cased special joints
		A	B	C
Silt and clay	0	50	40	30
Very fine sand	8	60	50	40
(0.1 mm. and less)	16	70	60	50
Fine sand to	0	75	65	55
Medium sand	8	90	80	70
(0.1 mm. to 0.5 mm.)	16	105	95	85
Coarse sand	0	175	165	155
Fine gravel and well filled mixed gravel	8	200	190	180
(0.5 mm. to 2.0 mm.)	16	240	230	220

TABLE 2

Pump capacity 1,000 gpm.—15-ft. screen

Character of soil	Degree of slope	Type of structure containing pollution		
		Cesspools, privies, and clay pipe sewers	Cast-iron pipe and metal tanks	Sewer connections with extra-cased special joints
		A	B	C
Silt and clay	0	100	90	80
Very fine sand	8	120	110	100
(0.1 mm. and less)	16	140	130	120
Fine sand to	0	150	140	130
Medium sand	8	180	170	160
(0.1 mm. to 0.5 mm.)	16	210	200	190
Coarse sand	0	350	340	330
Fine gravel and well filled mixed gravel	8	400	390	380
(0.5 mm. to 2.0 mm.)	16	480	470	460

A—Computed by formula.
B—Arbitrary deduction of 10 ft. from A for reducing the possibility of contamination.
C—Deduction of 10 ft. from B when amount of contamination escaping into the soil is further limited. Column C represents the minimum distance for any type of construction.

Let $P = 500$ gpm.
$I = 15$.
$K = 0.11$.
$S = 0$.

$$D = \frac{500}{2 \times 3.14 \times 15 \times .11} = 50.$$

For $S = 8°$ $D = 58$ ft., say 60 ft.
For $S = 16°$ $D = 68$ ft., say 70 ft.

The formula can be used to determine the approximate safe distance for any combination of screen, pump, soil, and slope with the proviso that no distance shall be less than the 50, 40, and 30 ft. that head the 500-gpm. Table. Hand pumps and power pumps of small draft will fall, therefore, under this classification.

* * *

The two paragraphs following are quoted from "Ground-Water Supplies. Progress Report of the Committee on Ground-Water Supplies Conference of State Sanitary Engineers, 1936" (Supplement No. 124 to the Public Health Reports).

"Toilets, sewers, floor drains, soil pipes, main drains, or other pipes which are connected directly to a storm or sanitary sewer, or through which water or sewage from any source may back up, should not be located nearer than 50 ft., horizontally, to any well, spring, infiltration system, pumping apparatus, suction main, air pipe, air compressor, filter, or other feature of any ground-water supply. In special cases, where it is impossible or not practical to obtain a 50-ft. distance, special construction to provide additional safeguards is necessary. In no case shall such fixtures or piping be nearer than 30 ft. to a well. All such sewers, drains, and pipes, or parts thereof, which must be more than 30 ft. and which are less than 40 ft., horizontally, from any such water supply feature, should be constructed of extra heavy cast-iron pipe with tested watertight leaded joints. In this zone, joints should be further protected against leakage by a substantial slip-over sleeve extending at least 6 in. from each side of the joint. The annular space between the pipe and the sleeve shall be filled with asphalt or material such as sewer-joint compound, or closed with rubber gaskets. All such sewers as lie between 40 and 50 ft. of the ground-water supply may be of extra heavy cast-iron pipe with tested watertight leaded joints. Toilets, sewers, soil pipes, or drains should not be located on the first floor directly above the pump room

floor, or where leakage therefrom can reach any source of water supply or pump room.

"Floor drains constructed of cast-iron pipe with leaded joints may be located as close as 2 ft. to a ground-water supply, provided they do not connect to a storm or sanitary sewer, and provided they discharge only to the ground surface or to a gravel pocket, which is well removed from contact with sewage or other waste. The cast-iron pipe should be carried to a point at least 4 ft. outside the building walls and connected to other suitable pipe which discharges at least 30 ft. from the ground-water supply."

Item 4—Minimum Depth of Casings and Curbings

All well and spring basin casings or curbings shall extend a safe distance below the ground surface.

Public health reason—A watertight casing or curbing which extends a safe distance below the ground surface is essential to insure exclusion of contaminated water from a well.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) The watertight well casing or curbing extends to a minimum depth or not less than 10 ft. below the ground surface and preferably 10 ft. below the ground water table. The casing should be carried through an impervious stratum above the water-bearing stratum and a tight seal made between this impervious stratum and the well casing to exclude undesirable water strata and surface water. Where such impervious strata may not exist, the well should be grouted throughout its entire depth to seal off all but the water-bearing stratum from which water is to be drawn.

(2) The watertight casing for a driven point well extends the full depth of the well to the water-bearing stratum.

(3) In the case of springs, the water enters the inclosing structure of springs or infiltration systems at points 10 ft. below the ground surface. In cases where the 10-ft. distance is not obtainable without sealing, cutting off, or diverting the underground source, the springs may be protected by placing earth filling over the area involved (50-ft. radius from the spring) to provide the necessary depth of 10 ft. of earth over the points of flow. If this is impracticable, adequate treatment should be provided in accordance with the provisions of item 20 of this manual.

Item 5—Construction and Use of Casings and Curbings

All ground water supplies shall have a properly constructed and installed outside watertight casing or curbing extending a safe distance above and below the ground surface.

Public health reason—A properly constructed and installed watertight casing or curbing is essential to prevent the entrance of surface or subsurface contamination into the well.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) If metallic casings are used, the casing is new standard steel, wrought iron, or cast iron as specified in the following tables or equal, and the pipe sections are threaded or welded so as to be watertight.

(*a*) In establishing the depth of casing or curbing below the ground surface, the measurement is made from the established grade in the immediate vicinity of the source. The casing or curbing shall extend as far as practicable below the natural ground level, but

not less than 10 ft., and excessive depths of fill should be avoided.

(*b*) The annular space between the outside well casing and the well hole, for drilled wells, is filled with not less than 1½ in. of impervious cement grout to a depth of at least 10 ft. and to such greater depth as may be required by the health officer. Refer to appendix A for discussion of cement grouting of drilled wells.

(*c*) Telescoping casings of different diameters, in a drilled well, overlap at least 8 ft. and the annular space between such casings is filled with not less than 1½ in. of impervious cement grout or with a lead packer to prevent admission of undesirable ground water or surface drainage.

(*d*) The outside casing is not used as a suction or working barrel for pump plungers.

(2) The casing extends not less than 6 in. above the established ground surface at the well or the floor of the pump house.

(3) If concrete pipe, vitrified tile pipe, cement-asbestos pipe, galvanized well casing, corrugated metal pipe, or brick are used for curbings for wells or springs, the following requirements are satisfied:

(*a*) Vitrified tile pipe, cement-asbestos pipe, galvanized well casing,

TABLE 3*

Steel and wrought-iron well casing

Well casing						Couplings	
Nominal size in inches	Weight, pounds per foot (threads and couplings. inclusive)	Thickness in inches	Diameter in inches		Threads per inch	Length in inches	External diameter in inches
			Internal	External			
1	1.68	0.133	1.049	1.315	11½	1⅞	1.576
1¼	2.28	.140	1.380	1.660	11½	2⅛	1.950
1½	2.73	.145	1.610	1.900	11½	2⅜	2.218
2	3.68	.154	2.067	2.375	11½	2⅝	2.760
2½	5.82	.203	2.469	2.875	8	2⅞	3.276
3	7.62	.216	3.068	3.500	8	3⅛	3.948
3½	9.20	.226	3.548	4.000	8	3⅝	4.591
4	10.89	.237	4.026	4.500	8	3⅝	5.091
4½	12.64	.247	4.506	5.000	8	4⅛	5.591
5	14.81	.258	5.047	5.563	8	4⅛	6.296
6	19.18	.280	6.065	6.625	8	4⅛	7.358
8	25.00	.277	8.071	8.625	8	4⅝	9.420
10	35.00	.307	10.136	10.750	8	6⅛	11.721
12	45.00	.330	12.090	12.750	8	6⅛	13.958
14 od	57.00	.375	13.250	14.000	8	7⅛	15.446
15 od	61.15	.375	14.250	15.000	8	7⅛	16.446
16 od	65.30	.375	15.250	16.000	8	7⅛	17.446
17 od	73.20	.375	16.214	17.000	8	7⅛	18.683
18 od	81.20	.375	17.182	18.000	8	7⅛	19.921
20 od	90.00	.375	19.182	20.000	8	7⅝	21.706

Where pipe sections are connected by welded joints, threading and couplings are not essential.
* From Wisconsin Well Construction Code.

TABLE 4 *

Threaded cast-iron well casing

Well casing							Couplings	
Nominal diam. (inches)	Weight, pounds per ft.	Wall, thickness in inches	Diam. in inches		Maximum length of string, in ft.	Threads per inch	Length in inches	External diam. in inches
			Internal	External				
3....	11.2	0.360	2.780	3.500	1,200	8	3¾	4.125
3....	12.2	.360	3.155	3.875	1,200	8	3¾	4.750
3....	12.7	.360	3.240	3.960	1,200	8	3¾	4.875
4....	15.0	.370	3.760	4.500	1,200	8	4	5.250
4....	17.0	.380	4.040	4.800	1,200	8	4	5.750
4....	17.2	.380	4.240	5.000	1,200	8	4	6.000
5....	18.5	.380	4.803	5.563	1,200	8	4¼	6.375
6....	24.4	.400	5.825	6.625	1,200	8	4½	7.500
6....	27.0	.430	6.040	6.900	1,200	8	4½	7.875
6....	28.1	.430	6.240	7.100	1,200	8	4½	8.250
8....	36.7	.460	7.705	8.625	1,400	8	5	9.625
8....	42.0	.500	8.050	9.050	1,400	8	5	10.125
8....	43.1	.500	8.300	9.300	1,400	8	5	10.625
10....	52.1	.520	9.710	10.750	1,400	8	5¼	12.000
10....	59.0	.570	9.960	11.100	1,500	8	5¼	12.500
10....	60.5	.570	10.260	11.400	1,500	8	5¼	13.000
12....	69.2	.580	11.590	12.750	1,500	8	5¾	14.125
12....	77.0	.620	11.960	13.200	1,500	8	5¾	14.625
12....	78.3	.620	12.260	13.500	1,500	8	5¾	15.250
14....	99.0	.690	13.920	15.300	1,500	8	6¼	16.875
14....	102.0	.690	14.270	15.650	1,500	8	6¼	17.625
16....	122.0	.750	15.900	17.400	1,600	8	6¾	19.250
16....	126.0	.750	16.300	17.800	1,600	8	6¾	20.000
18....	152.0	.830	17.840	19.500	1,600	8	7	21.250
18....	156.0	.830	18.260	19.920	1,600	8	7	22.375
20....	179.0	.880	19.840	21.600	1,600	8	7½	23.625
20....	183.0	.880	20.300	22.060	1,600	8	7½	24.625
24....	243.0	1.000	23.800	25.800	1,600	8	8¼	28.125
24....	248.0	1.000	24.320	26.320	1,600	8	8¼	29.250

Where pipe sections are connected by welded joints, threading and couplings are not essential.
* From Amer. Pipe Manual 1937, Amer. Cast Iron Pipe Co., pp. 171–172.

corrugated metal pipe, and concrete pipe shall be surrounded by not less than 6 in. of concrete to a depth of at least 10 ft. The surrounding concrete wall shall be not less than 6 in. thick, properly reinforced, and the concrete shall be so placed as to be free from voids. Wherever practical, the wall shall be poured in one operation, but in no case shall there be a construction joint within 10 ft. of the top of the curbing. Where construction joints are essential at points more than 10 ft. below the ground surface they shall be left rough and shall be washed and brushed with neat cement grout prior to pouring concrete.

The concrete used in the construction of any ground water supply units should be composed of 1 part Portland cement, 2 parts sand, and 4 parts gravel by volume. Clean, hard, tough, and durable aggregates should be used. The maximum diameter of aggregate

particles should not exceed one-fifth of the minimum width between forms.

Hydrated lime to the extent of 10 per cent of the volume of cement may be added to increase fluidity and facilitate placement of concrete. The use of lime is particularly applicable in the case of concrete used for spring and dug well casings.

(*b*) Single brick walls. Single brick walls shall be surrounded by not less than 6 in. of concrete as described in paragraph (*a*).

(*c*) Double layer brick walls have an inch thick layer of 1 to 1 Portland cement mortar applied either to the exterior of the brick wall or between the two rings of brick. Both the vertical and horizontal joints in the two rings of brick are staggered. The brick is common brick, compact in texture, hard burned entirely through, sound and uniform in quality and free from lumps and cracks.

(*d*) Well and spring basin curbings extend at least 6 in. above the established ground surface.

(*e*) The peripheral space between a dug well or a spring basin curbing and the original earth formation is filled with thoroughly compacted clean puddled clay or equivalent materials.

(*f*) A separate inside pipe for conducting water from a well, commonly known as a drop pipe, is provided.

Item 6—Gravel Treated Wells

When gravel is placed in the annular space between the excavation line and the outside of the well casing, the gravel surface shall terminate a safe distance below the ground surface and the annular space above the gravel surface shall be filled with impervious material. It is desirable to disinfect the gravel used with a chlorine solution because it is practically impossible to do so after the gravel has been placed.

Public health reason—Proper filling of the annular space between the excavation line and the outside of the well casing with impervious material for a safe distance above the gravel surface is essential to prevent contaminated surface water from reaching the source of supply through the gravel layer. The use of contaminated gravel may result in unsatisfactory bacteriological tests over a long period of time and even if this gravel contamination has no sanitary significance it may mask the true quality of the ground water source.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) The gravel surface terminates not less than 10 ft. below the ground surface.

(2) The annular space between the excavation line and the outside of the well casing, above the gravel surface, is filled with thoroughly compacted puddled clay, mortar, or cement grout.

(3) Gravel used for treating wells is disinfected with a chlorine solution immediately before application to the well.

Item 7—Covers, Platforms, and Floors

Every cover, pump platform, or pump room floor shall be watertight and elevated above the adjacent ground level and its surface sloped to facilitate the rapid removal of waste water.

Public health reason—A properly

elevated, watertight, well-drained cover or floor promotes cleanliness and is essential to divert contaminated surface water away from the source.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) The cover, pump platform, or pump room floor is made of reinforced watertight concrete.

(2) The concrete is sloped from the center of the well casing or pipe sleeve to the outer edges of the slab or the drain, and the slab at its outer edges is not less than 4 in. thick.

(3) In the case of drilled or bored wells equipped with hand-operated pumps, the concrete slab extends not less than 2 ft. from the well casing in all directions.

(4) In case power pumps are mounted over the casing, the casing extends not less than 6 in. above the pump platform or floor and not less than 1 in. into the pump base in accordance with the provisions of item 11 (B) of this manual.

(5) In the case of hand pumps, the casing or pipe sleeve extends not less than 1 in. above the pedestal on which the pump base rests.

(6) The cover of a dug well or spring basin is watertight, properly grouted in place, and its edges extend at least 2 in. beyond the outer edge of the wall or curbing of the well or spring basin.

(7) In the case of drilled or bored wells, the cover, pump platform, or pump room floor rests on thoroughly compacted earth.

Item 8—Well Seals or Covers

Every well shall be provided with a watertight seal or overlapping cover at the top of the casing or pipe sleeve.

Public health reason—A watertight seal or overlapping cover at the top of the casing or pipe sleeve is essential to prevent contaminated water or other deleterious material from entering the well through the annular opening at the top of the well casing or pipe sleeve.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) In case the pump and drop pipe are not installed immediately after the casing or pipe sleeve is installed, the top of the casing or pipe sleeve is provided with a watertight seal or overlapping cover at the top until the installation is completed and a permanent seal is provided.

All wells should be kept permanently sealed, or properly covered, at the top at all times, except when necessary to remove the seal for the purpose of inspection or to accomplish necessary installations, repairs, or other essential operations.

(2) The casing or annular opening between the casing and drop pipe is provided with a watertight seal or overlapping cover, making a watertight connection to drop pipe, at the top. This item shall be satisfied when a properly constructed pump base overlaps the casing or pipe sleeve at the top.

Item 9—Well Vents

Well vents shall be constructed and installed to retain atmospheric pressure conditions in the well casing and to prevent the entrance of contamination.

Public health reason—Proper construction and installation of a well vent is essential to prevent the entrance of insects and contaminating material into the well. Creation of a partial vacuum within the well might tend to introduce pollution or cause collapse of the well wall or casing.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) Every well in which the drawdown is 10 ft. or more, and which has equipment or appurtenances installed therein, is provided with an adequate air vent.

(2) The air vent is constructed of metal tubing or pipe and connected so as to be watertight.

(3) The open end of the vent is screened and terminated in a downward direction through use of an elbow or equivalent means and the lower end of the outlet is not less than 12 in. above the top of the well casing, and in no case less than 18 in. above the floor of the pump room.

The vent shall be screened with 16-mesh brass or bronze screen, or holes $\frac{1}{4}$ to $\frac{1}{2}$ in. in diameter may be drilled in the capped, downward directed portion of the vent pipe and 16-mesh brass or bronze screen tightly fitted over these holes. The cross-sectional area of these holes should be at least equal to the cross-sectional area of the vent pipe.

Item 10—Well Pits

Wellheads, well casings, pumps, pumping machinery, exposed suction pipes, or valve boxes connected with a suction pipe shall not be located in any pit, room, or space extending below the ground surface: *Provided,* That existing pits may be provisionally accepted only if constructed in accordance with the requirements of the state health department.

Public health reason—Excavations or subsurface structures such as well pits provide means for the accumulation of contaminated surface or shallow subsurface water which may contaminate the water supply.

A number of sanitary pitless underground pumps are available on the market which eliminate the installation of underground discharge pumps in pits for frost protection. Standard parts can be purchased and assembled in such a way as to accomplish the same results. The need for frost pits may be avoided by the use of bleeders or weep holes located in the drop pipe at a point below the frost line in order that the water in the pump and drop pipe may run back into the well after pumping has been discontinued. The need of locating pump room floors below the ground level may be avoided by providing an insulated pump house to protect the pumping equipment and appurtenances from freezing. If additional protection is essential during unusually cold weather, it can be provided at a nominal cost by installing a thermostatically-controlled electric heater or other types of heating units in the pump house.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) In the case of new installations, wellheads, well casings, pumps, pumping machinery, valve boxes connected with a suction pipe, or exposed suction

pipes are not located in any pit, room, or space extending below ground level: *Provided,* That submersible pumps constructed to operate below the water level within the well casing may be installed on approval of the health officer.

(2) In the case of existing ground water supplies, such pits housing well-heads, well casings, pumps, pumping machinery, suction pipes, or valves connected with a suction pipe shall be accepted provisionally only if constructed or reconstructed in accordance with requirements of the state health department. It is recommended that provisionally accepted pits conform with the following minimum requirements as well as with any requirements set up by the state health department for their approval of specific installations:

(*a*) Pits shall be of watertight construction with walls extending at least 6 in. above the established ground surface at all points.

(*b*) Pits shall be provided with a watertight concrete floor sloping to a drain which discharges through a cast-iron line not less than 4 in. in diameter to the ground surface at a lower elevation than the pit, and at least 30 ft. from it; or if this is impossible, to a watertight concrete sump, in the pit, equipped with an automatic sump pump discharging through a steel or cast-iron line to the ground surface at least 30 ft. from the pit. (*See* item 12 (B).)

(*c*) Pits shall be provided with a concrete base for pumps, or pumping machinery, so that such units shall set at least 12 in. above the floor of the pit.

(*d*) Pits shall be provided with a satisfactory housing or cover in all cases.

Item 11—Construction and Installation of Pumps

All water pumps shall be so constructed and installed as to prevent contamination of the water supply.

Public health reason—Proper construction and installation of pumps is essential to prevent contamination from entering the well by means of the pump or pump mounting.

Item 11 (A)—Hand Pumps

Hand pumps may be mounted by setting the pump over the pipe sleeve and anchoring the base of the pump to the concrete pedestal or by mounting the base of the pump on a metal flange which is anchored rigidly to the pipe sleeve. The latter method of mounting a hand pump is preferable, inasmuch as this method provides a more permanent and rigid connection which is easily accessible when repairs are made. Hand pumps which are anchored to the concrete pedestal by means of nuts and bolts become loosened, resulting in an unsatisfactory installation. Where a hand pump is mounted on a flange, the pipe sleeve should extend at least 6 in. above the top of the concrete platform.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) Hand pumps are of the force type with cylinders placed below or near the water level so that priming is not necessary.

(2) The pump base is watertight and of the solid one-piece recessed type, cast integrally with or threaded to the pump column or stand.

(3) The pump base is of sufficient diameter and depth to permit the well casing to extend not less than 1 in. into the base of the pump.

(4) The pump base is rigidly fastened to a metal flange by means of bolts and nuts, or by equivalent means.

(5) The pump head is of the closed type provided with a pump rod stuffing box.

(6) The pump spout is of the closed downward directed type.

(7) Suitable gaskets are used between the pump base and the flange to insure a watertight joint.

Item 11 (B)—Power Pumps

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) Any pump or power unit placed immediately over the well casing or pipe sleeve has a watertight metal base to form a cover for the well. The base plate is recessed on the underside to permit the casing or pipe sleeve to extend into it at least 1 in. above the level of the concrete foundation upon which the base of the pump or power unit rests, thus forming an overlapping cover with edges projecting below the top of the casing or pipe sleeve.

Where necessary the casing head can be enlarged or decreased in diameter by means of a pipe sleeve extension securely attached to the casing so as to be watertight. On flat base plates and other shapes where radial ribs interfere, a skirt projecting downward at least 1 in. below the top of the well casing may be welded to the outside edge of the base plate to form the overlapping cover for the well casing.

In installations having an open type pedestal for pump or power unit and having ample space to permit installation and removal of a watertight metal cover or of a lead packing or of a seal of sand and asphalt compound or cement grout, this type of closure may be used in lieu of the base plate type of cover, specified above, for the annular space between the suction pipe and the well casing. The well casing must extend at least 6 in. above the established ground surface at the well or the floor of the pump house, as required in paragraph (2) of item 5 of this manual.

(2) In the case of power pumps which are not placed directly over the well, the well casing extends at least 6 in. above the established ground surface at the well or the floor of the pump house and the annular space between the well casing and suction pipe is closed with a watertight cover or lead seal to prevent the entrance of contamination into the well.

(3) In case a submersible pump is installed within the well casing below the water level, the motor is enclosed completely in a watertight metal casing constructed to prevent oil from coming in contact with the water, and the oil is conveyed to the motor housing through noncorrodible heavy metal tubing.

(4) Any opening in the base plate of the pump or annular opening made by passing a pipe through the pump base is made watertight to a point above the spill line of the webbing around the plate. Such an opening may be threaded and a nipple extend-

ing above the spill line of the webbing screwed into it. The annular opening between the nipple and pipe passing through it may be leaded, fitted with a stuffing box and packing, or provided with an overlapping cover welded to the pipe. If there are any other openings in the base plate they are threaded and fitted with metal screw plugs.

(5) The pump or power unit base is anchored rigidly to the well casing or the pump platform.

(6) The discharge tee, check valve, and gate valve are located above the pump room floor.

(7) The discharge line from a power pump is provided with a sampling cock with the outlet terminating in a downward direction.

Item 12—Pump House

The pump house shall be constructed properly to prevent flooding, shall be provided with adequate floor drainage, and if plumbing fixtures are to be provided they should be designed and installed properly.

Item 12 (A)—Construction to Prevent Flooding

Public health reason—Proper construction of the pump house is essential to eliminate the possibility of the interior of the structure being flooded during emergencies.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) The pump house is provided with a doorway and a door at least 6 sq. ft. in area which opens outward and extends to the floor.

(2) Pump houses located on side hill slopes have not less than 50 per cent of the floor area above ground level and the door located on that part of the floor above ground level.

Item 12 (B)—Drainage of Floors

Public health reason—A well-drained concrete floor promotes cleanliness and facilitates the removal of waste water.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) A floor drain is provided and is constructed of cast iron or equivalent material with an outlet not less than 4 in. in diameter.

(2) The inlet to the floor drain is located not less than 2 ft. from the outer edge of the casing or pipe sleeve.

(3) A cast-iron pipeline with watertight leaded joints is connected to the floor drain and carried to a point not less than 4 ft. outside the building walls and connected to other suitable pipe which discharges onto the ground surface not less than 30 ft. from the source: *Provided,* That where the drain line cannot be extended to the ground surface on a uniform grade toward the outlet, the line may discharge into an absorption pit located not less than 30 ft. from the source. The drain line should be laid at a grade toward the outlet of not less than $\frac{1}{8}$ in. per ft. except that for a floor drain installed for the purpose indicated and in the manner specified in this item 12 (B), the requirements of item 3, "Distances to Sources of Contamination," shall not apply thereto.

However, such drains shall not be connected to a storm or sanitary sewer; they may discharge to the ground surface or to a dry well which is well removed from contact with sewage or other wastes.

Item 12 (C)—Plumbing Fixtures in Pump House

Public health reason—Properly designed and installed plumbing fixtures will eliminate the public health hazard caused by the back siphonage of contaminated liquid wastes from faulty plumbing fixtures into the water supply piping.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) Toilets, sewers, soil pipes, or drains are not located on the first floor directly above the pump room floor, or where leakage therefrom can reach any source of water supply or pump room.

(2) The locations of toilets, sewers, soil pipes, or drains in the pump house are approved by the health officer, and the installation conforms to the requirements of item 3 of this manual, "Distances to Sources of Contamination."

(3) All plumbing fixtures comply with the Federal Specifications for Plumbing Fixtures, March 1940, WW-P-541a, or its equivalent. The requirements of these specifications with respect to air gaps and back flow preventers are strictly enforced.

Item 13—Lubrication of Pump Bearings

Pump bearings situated in any well below the pump room floor or platform shall be lubricated with water of a safe sanitary quality.

Public health reason—Lubrication of pump bearings, situated in a well below the pump room floor, with oil, grease, or water other than of a safe sanitary quality may result in contamination of the water supply.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) Pump bearings situated in any well below the pump room floor or platform are lubricated with water taken from within the well, or reservoir, or distribution system supplied with water from the original source of water supply, or from another supply which meets with the requirements of the health officer.

(2) In the case of existing installations using oil-lubricated bearings, the oil is stored and handled so as not to expose it to contamination.

Item 14—Priming of Power Pumps

Priming type power pumps shall be primed with water of a safe sanitary quality applied from properly protected equipment.

Public health reason—Priming of power pumps with water other than of a safe sanitary quality may result in contamination of the water supply as the result of priming water being forced into the distribution system.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) Power pumps are primed with water taken from the original source for which the pump is used or from a reservoir or distribution system supplied with water from the original source of water supply or from another supply which meets the requirements of the health officer.

(2) Priming devices are so constructed and installed as not to expose the water to dust, drippings, or other sources of contamination.

Item 15—Protection of Suction Pipes

All subsurface suction piping leading from detached wells or reservoirs shall be protected adequately against the entrance of contamination.

Public health reason—The suction created in the pipeline when water is pumped may result in contaminated ground water or surface water being drawn into the line through breaks or defective joints in the suction line.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) The pumps are placed directly over the well, sump, or reservoir wherever practicable, and the suction pipe, where located above ground, is in a frostproof box.

(2) In the case of a suction pipe rising to a pump house the outer casing extends not less than 6 in. above the platform or floor surface.

(3) The annular space between the protective casing pipe and the suction pipe is provided with a watertight seal at the top.

(4) Subsurface suction piping is not less than 10 ft. below the ground, either natural or fill.

(5) All that part of any suction piping within 10 ft. of and below the ground surface is surrounded by a watertight outer casing pipe or protected by equivalent means. In case of filled ground, an outer protective casing shall be used, regardless of depth of suction pipe.

Frequently the discharge lines of well pipes are under negative pressure. This is caused by water running back down into the well when the pump stops. These sections of pipe should be protected against contamination by methods similar to these recommended for suction pipes.

Item 16—Valve Boxes

Every valve box on a buried suction pipeline shall be constructed and installed properly.

Public health reason—Proper construction and installation of valve boxes are essential to prevent contaminated surface water from entering the valve box and accumulating around the valve. Valves submerged by surface water may result in contamination being drawn into the suction line through defective valves and connections.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) Valves located on buried suction lines are protected with valve boxes which project not less than 6 in. above the floor if in a building or room, and not less than 12 in. above the ground surface if not enclosed in a building.

(2) The tops of all such valve boxes are provided with watertight overlapping covers.

(3) In case valves are installed on buried suction lines located 10 ft. or more below the ground surface, the valve box is watertight for not less than 10 ft. below the ground surface, and when the space between the valve box and the natural ground formation is filled with compacted puddled clay or equivalent materials.

(4) In case valves are installed on buried suction lines located less than 10 ft. below the ground surface, the valve is enclosed completely in a watertight valve box. When valves cannot be enclosed completely in a valve box, the box shall be watertight and the opening between the base of the valve box and the valve dome or cover shall be sealed so as to be watertight.

Valves on buried suction lines should be avoided wherever possible by placing suction pipes above the pump room floor or above the ground surface.

Item 17—Manholes and Covers

Every manhole opening on spring structures, dug wells, or valve chambers shall be curbed above the adjoining surface and provided with an overlapping watertight cover.

Public health reason—Manhole openings that are curbed and provided with an overlapping watertight cover are essential to prevent contaminated surface water from entering the manhole opening.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) The manhole opening is curbed to a height of at least 6 in. above the adjoining surfaces.

(2) The manhole cover is watertight and overlaps the curbing and extends downward around it for not less than 2 in.

(3) The manhole cover is kept in place by means of a hasp and lock, or by equivalent means.

(4) In case metal manhole covers are provided, the covers are welded, formed, or molded to form the overlap for the manhole opening and the metal shall be at least 12 gage.

Item 18—Airlift Systems

The air compressor and appurtenances for any airlift system or mechanical aerating apparatus used in connection with a ground water supply shall be installed and operated properly.

Public health reason—Proper construction, installation, and protection of air compressors and appurtenances is essential to prevent the entrance of insects, birds, or other contaminating materials, and to minimize the entrance of dust.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) Watertight metal tubing, pipe, or equivalent materials are used for air intakes.

(2) The open end of an air intake of any airlift system or mechanical aerating apparatus is not less than 6 ft. above the floor surface if indoors, 10 ft. above the ground surface if outdoors, and 2 ft. above a roof of a building through which it may project.

(3) The open end of the air intake

is screened with 16-mesh brass or bronze screen, terminated in a downward direction, and an air filter installed in the intake line.

(4) The air compressor is located in a room as free as possible from dust and at such elevation that flooding of the equipment will be made impossible.

(5) The compressed air from the compressor is discharged into an air storage tank, oil trap, or filter designed to remove from the compressed air oil or oil mist which may have entered during its passage through the compressor.

Item 19—Cross-Connections

There shall be no physical connection between a safe public ground water supply and any other water supply not of equal sanitary quality and under as rigid official supervision, and there shall be no connection or arrangement by which unsafe water may enter a safe public ground water supply system.

Public health reason—This item is important, inasmuch as cross-connections have been found to be one of the principal causes of water-borne disease outbreaks. Wolman's and Gorman's figures show that during a 7-yr. period (1930–36) 14 reported water-borne outbreaks resulting in 139 cases of typhoid fever and 563 cases of diarrhea were due to cross-connections between safe and polluted water supply systems.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

There are no cross-connections, backflow connections, emergency intakes, bypass,[2] or other arrangements by means of which polluted water or water or unknown or questionable quality may enter a safe public ground water supply system: *Provided,* That water of a safe sanitary quality may be supplied to any other system containing water of questionable quality only by means of an independent line discharging at least two pipe diameters and not less than 6 in. above the rim of storage units open to atmospheric pressure.

Item 20—Bacteriological, Physical, and Chemical Quality of Water

The bacteriological, physical, and chemical quality of water furnished to consumers from a public ground water supply shall be not less than the requirements of the Public Health Service[1] for drinking and culinary water used on common carriers operating in interstate commerce; when necessary, the water shall be treated to conform with the Public Health Service requirements.

Public health reason—Diseases such as typhoid fever, cholera, dysentery, and other enteric diseases may be transmitted through the use of contaminated drinking water, and physiological disturbances may occur from the use of chemically or physically unsatisfactory water.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) Untreated waters meet in all respects the requirements of this manual.

[1] Reprint No. 2440, Public Health Reports. Available from Superintendent of Documents for 10 cents.

[2] These terms are defined in section 1 of this manual.

Only those supplies meeting the bacteriological, physical, and chemical requirements of the United States Public Health Service Drinking Water Standards as shown by satisfactorily regular and frequent sanitary inspections and laboratory tests shall be approved for use without treatment.

(2) Public ground water supplies subject to a low degree of contamination (average coliform content of not more than 50 per 100 ml. in any month), but otherwise meeting all requirements of this manual, are given treatment consisting of chlorination and storage.

Chlorination facilities including equipment, control, and operating procedures shall be approved by the health officer. Free chlorine should be in contact with the treated water for not less than 20 min., or chloramine preferably for at least 3 hr. before the treated water reaches the first consumer. Where necessary, baffle walls shall be used to prevent short-circuiting of the water from the inlet to the outlet of the detention reservoir so that the water will remain in the reservoir for the full flow-through period of time. The treated effluent shall meet the bacteriological requirements of the Public Health Service Drinking Water Standards.

Treatment shall be employed when there is a possibility of contamination reaching the water supply source and rendering it unsafe for domestic use. Treatment, however, should not be used permanently to overcome a defect of construction which can and should be corrected.

Where a treated underground supply is in use and an equally good untreated supply can be obtained, the treated supply shall be considered as temporary, to be used only until the untreated supply can be made available. Treatment may then be used as an additional safeguard.

On a site where the earth formations permit the rapid movement of ground water, such as coarse gravel, fissured rock, solution channels, and similar formations, the ground water cannot be considered safe, and adequate treatment shall be provided.

(3) Treatment consisting of sedimentation, filtration, and disinfection is provided for waters containing numbers of coliform bacteria averaging over 50 per 100 ml. but not more than 5,000 per 100 ml. in any month and exceeding 5,000 per 100 ml. in not more than 20 per cent of the samples examined in any month.

Treatment processes, operation, and control for this class of water shall be approved by the state department of health. The treated effluent shall meet the bacteriological requirements of the Public Health Service Drinking Water Standards.

(4) Ground water supplies subjected to softening treatment or treatment for mineral removal employing various processes using chemicals in contact with the water, aeration, filtration, and similar methods are chlorinated before delivery for consumption.

Item 21—Plant Supervision and Control

All public ground water supplies shall be under the supervision and control of a competent operator.

Public health reason—A competent operator is essential to prevent contamination of the water supply during reconstruction work, repair to equipment and appurtenances, or in the operation of the plant.

Satisfactory compliance—This item

shall be deemed to have been satisfied when:

(1) All plants are under the supervision of a competent operator approved by the health officer, and in those states which have licensing requirements for water works operators, such requirements are met by the operator.

(2) In case of untreated ground water supplies, the operator is available on call in any emergency.

(3) In case the treatment of the water consists of chlorination and storage only, the operator visits the plant not less than twice each day and is available on call in any emergency.

(4) In case additional treatment of the water supplements chlorination and storage, the supervision of the plant meets the requirements of the health officer.

(5) In case of treated ground water supplies, the operator keeps records essential to the control and operation of the plant and submits copies of such records as the health officer may require.

Item 22—Water Sampling

Chemical analyses and bacteriological examinations of water samples and tests for residual chlorine shall be made by approved methods and at proper intervals.

Public health reason—Chemical analyses and bacteriological examination of water samples and tests for residual chlorine are essential to guide the operator in running the plant and to determine whether the water is of satisfactory sanitary quality.

The recommended minimum intervals at which samples should be collected from all ground water supplies for bacteriological examination and residual chlorine tests are presented in the following tabulation:

In addition to bacteriological examinations and residual chlorine tests for underground water supplies requiring aeration, sedimentation, and filtration, or any combination thereof with chlorination and storage, the following laboratory tests should be made at frequent intervals where they are essential to control the treatment plant operation: temperature of air and water, turbidity, color, alkalinity, hydrogen-ion concentration (pH), and hardness. Occasionally special tests may be necessary such as for residual alum, iron, manganese, or other undesirable constituents of the final effluent. Where prechlorination is used in addition to postchlorination, tests for residual chlo-

	Minimum interval of sampling for—	
Type of treatment	*Bacteriological examination* [1]	*Residual chlorine tests*
None	1 month	
Chlorination and storage only	1 week	At least once in each successive 8-hr. period.
Aeration, sedimentation, and filtration, or any combination thereof with chlorination and storage	Daily	Do.

[1] The number of bacteriological samples to be collected from the distribution system per month should be in accordance with the requirements of the Public Health Service Drinking Water Standards as indicated in Fig. 1.

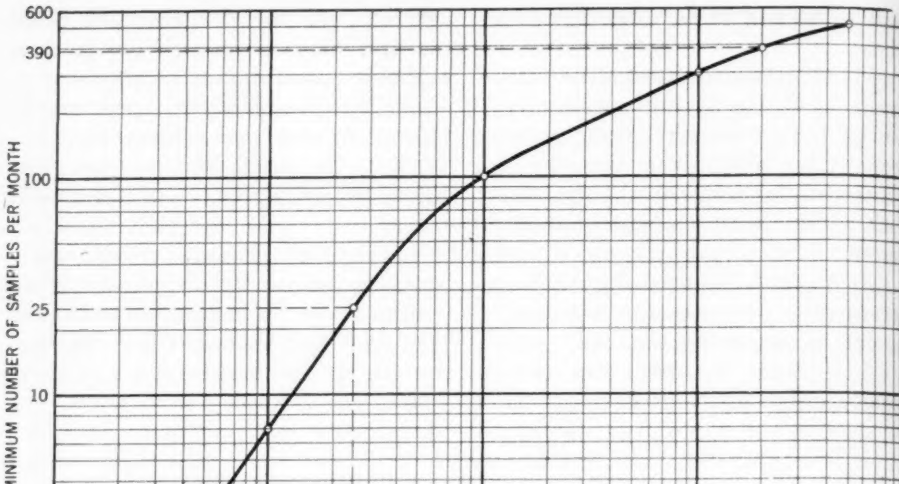


Fig. 1

rine should be made at each major stage of treatment, and, in the raw water, test for chlorine demand.

For operational control at the plant, the frequency of tests, particularly for turbidity, residual chlorine, bacterial count, and coliform organisms, though dependent on the character of water treated and on its variability, should be such that at least one test each 24 hr. and every day of the week will be carried out. For the larger plants, at least three sets of samples are usually collected daily for bacteriological tests. Determinations of turbidity and residual chlorine are made more frequently, sometimes at hourly intervals when the character of the raw or partly treated water is changing rapidly.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) All physical, chemical, bacteriological, and biological tests are made in conformity with "Standard Methods for the Examination of Water and Sewage," American Public Health Association, 8th Edition, 1936.

(2) Bacteriological and chemical tests of water samples from a newly developed or constructed ground water supply are made at least once following disinfection. The supply shall not be used for domestic purposes, where adequate treatment has not been provided, until the report on the bacteriological examination of water samples indicates that the water is of a safe sanitary quality.

(3) All ground water supplies are sampled for bacteriological, chemical and physical tests at such intervals as the health officer may require.

Item 23—Abandonment of Wells

Permanently abandoned wells shall be adequately filled with selected material to protect the water-bearing formation against possible contamination.

Public health reason—Adequate filling of a permanently abandoned well is essential to prevent contamination from being introduced into the water-bearing formation through an abandoned well, which may result in contamination of existing or future ground water supplies in the vicinity.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) Drilled or cased wells are filled completely with neat cement grout, concrete, or clean puddled clay.

(2) Driven wells are filled completely with neat cement grout, concrete, or clean puddled clay.

(3) Dug or bored wells are filled completely with puddled clay or its equal after as much as possible of the curbing is removed.

Item 24—Distribution

The distribution system shall be designed and constructed so as to prevent leakage of water due to defective materials, improper jointing, corrosion, settling, impacts, freezing, or other causes. Adequate valves and blowoffs, properly installed, shall be provided so that necessary repairs can be made with a minimum interruption of service.

Public health reason—Proper design and construction of the distribution system are necessary in order to deliver a safe water, to guard against contamination of water in the mains from outside sources, and to prevent leakage under conditions of decrease in pressure or negative pressure, and during repairs, break-downs, and installation of new mains.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) Cast-iron water mains are laid in accordance with the "Specifications for Laying Cast-Iron Pipe," adopted by the American Water Works Association (*see* Jour. A.W.W.A., **30**: 215 (1938)).

(2) Trenching operations are conducted so that the contents of sewers and drains do not enter the trench.

Measures should be taken to prevent defecation and urination in the trench. Suitable sanitary conveniences should be provided for the workmen, and wherever practicable such sanitary facilities should be connected to the sewers. Proper trench drainage should be provided and the end of the pipe should be kept closed except when joints are being made.

(3) Newly laid pipelines, before covering, are tested under a hydrostatic pressure 50 per cent in excess of the normal operating pressure after expelling all air from the pipe. The duration of each pressure test shall be at least 30 min.

All exposed pipes, fittings, valves, hydrants, and joints should be carefully examined during the open trench test. All joints made with lead showing visible leakage should be recaulked until tight. Where the joints are made with sulfur compound or with cement and show seepage or slight leakage only such joints as may be defective

should be cut out and replaced. Any cracked or defective pipes, fittings, valves, or hydrants discovered in consequence of this pressure test should be removed and replaced with sound material, and the test should be repeated until the pipe installation is satisfactory.

Suitable means should be provided for determining the quantity of water lost by leakage under normal operating pressure. No pipe installation should be accepted until or unless this leakage (evaluated on a pressure basis of 150 psi.) is less than 100 gal. per 24 hr. per mi. of pipe per in. nominal diameter for pipe in 12-ft. lengths, 75 gal. for 16-ft. lengths, and correspondingly varied for other lengths of pipe. In calculating leakage, allowance should be made for added joints in the pipeline above those incidental to normal unit lengths of pipe.

(4) Jointing materials are free from oil, tar, or greasy substances, are disinfected before use, examined bacteriologically after disinfection for freedom from coliform organisms, kept free from contamination, and applied dry; and when jointing materials will produce watertight joints, under all conditions to which the joint will be subjected.

(5) Water pipes are not laid in water, or where they can be flooded with water or sewage in laying, wherever this is practicable. When necessary to lay water lines below the water table or in wet ground, additional protection shall be provided for the joints, to insure watertightness, to the satisfaction of the health officer.

(6) Water mains crossing or laid near railroad tracks are constructed so that the pipe joints have a reasonable degree of flexibility and remain watertight.

The pipeline should be of such strength and tightness as to remain watertight under the loading and vibrations to which it will be subjected. Mechanical joints with rubber gaskets are suitable for such conditions. It is advisable in such situations to consult the railroad company and obtain approval for the crossing in advance of construction work.

(7) Laying of water pipes under water or under the bed of a stream is avoided and the crossing made on bridges, dams, or other structures sufficiently elevated so that the pipe will not be subject to immersion at any time, whenever this construction can be provided.

Above water crossings:

In cases where it is practicable to secure a satisfactory overhead crossing, particularly on bridges, consideration shall be given to the following items:

(*a*) The use of flexible pipe joints to maintain tightness under forces due to vibration and temperature variations and to prevent breaks and leaks at the points where the mains make sharp bends in leaving and returning to the ground.

(*b*) Protection of pipe from impact of runaway vehicles.

(*c*) Protection of pipe from flood waters or objects carried by flood waters.

Under water crossings:

In special cases where it is impossible or impractical to secure a satisfactory overhead crossing special construction to provide additional safeguards is necessary. These safeguards are briefly as follows:

(*a*) The pipe should not be laid on the stream bed or in the body of water. If an under crossing is made, it should be placed sufficiently far below the bot-

tom of the body of water to protect the pipe against freezing and being moved by currents, ice, floating objects, anchors, dredges, or being otherwise disturbed. The distance below the stream bed should not be less than 5 ft.

(*b*) The pipe should be of special construction having flexible watertight joints.

(*c*) All pipelines in under-water crossings should be provided with valves at both ends of the crossing so that the section can be isolated. The valves should be so located that they will not be subject to flooding.

(*d*) Permanent equipment should be installed for making periodic or continuous pressure tests for detecting leakage of the crossing.

(*e*) Sampling taps should be installed at each end of the crossing for the collection of samples for bacteriological examination.

(*f*) Provision should be made to blow off such sections of pipe to waste above ground level.

(*g*) Consideration should be given to the construction of under-water crossings in duplicate in order that continuous service and adequate pressure may better be maintained. Properly drained pipe tunnels deserve consideration because they facilitate inspection, repairs, and detection of leaks.

(8) Water lines are laid in trenches separated by at least 10 ft. of solid earth from sewer lines.

(9) Water pipes are laid, so far as possible, above the elevation of nearby sewers and at least 10 ft. laterally from them. Where this requirement cannot be met because of physical conditions, extra precautions are taken in securing absolute and permanent tightness of water pipe joints.

(10) Newly installed water mains are flushed thoroughly to waste through hydrants or other approved means to remove all dirt and foreign matter. The mains are disinfected in accordance with the following procedure and bacteriological tests indicate that the water conforms with the bacteriological requirements of the United States Public Health Service Drinking Water Standards before water conveyed in the mains is used for domestic consumption.

Disinfection procedure: After flushing the mains, introduce chlorine and water so that the mixture of water and chlorine entering the pipe shall contain a chlorine concentration of at least 50 ppm. Retain treated water in the pipes long enough to destroy all non-spore-forming bacteria. The period of detention should be at least 3 hr. and preferably longer. After the chlorine-treated water has been retained for the required time the chlorine residual at pipe extremities and at other representative points should be at least 5 ppm. If the residual is less than 5 ppm., the procedure should be repeated until a 5 ppm. residual is obtained. Upon completion of the disinfection process the water containing residual chlorine should be flushed from the system of pipes under treatment and water samples collected for the bacteriological examination mentioned above.

(11) All new plumbing is installed in accordance with the provisions of the state plumbing code and all existing plumbing which is not properly designed or properly installed, or both, is changed to conform with the state plumbing code as soon as the opportunity to do so presents itself.

Where state plumbing codes are not in effect the provisions of the "Plumbing Manual," Report BMS 66, issued by the National Bureau of Standards, should be followed. (During the war

emergency use of substitute materials for critical items required in BMS 66 will be permitted in accordance with requirements of the War Production Board.)

(12) The water service pipe is watertight and corrosion-resistant. Copper pipe and cast-iron pipe with specially protected joints such as cast-iron pipe with bell joint clamps are recommended.

Where a water service pipe crosses a street sewer at less than 6 ft. vertically above the sewer, or is within 10 ft. of it horizontally, all that part of the water pipe lying within these distances should be constructed preferably of copper or brass pipe connected to the iron pipe with a brass fitting. In such cases it is preferable to use copper or brass pipe from the water main to the house, and the house sewers should be constructed of extra heavy cast iron with watertight joints. (During the war emergency where priorities necessitate the use of materials other than brass or copper, extra heavy iron pipes should be used under these conditions.)

(13) The handling, repairing, testing, and installation of water meters are carried out in such a manner as to prevent introduction of contamination into the water supply system.

Before meters are installed they should be disinfected unless they are disinfected together with adjacent pipe before the system is placed in service. If meters are disinfected some considerable time before they are placed in the pipeline, the inlets and outlets should be capped to prevent the entrance of dirt, dust, or other contaminating material. Meters may be disinfected by passing a solution of chlorine of about 50 ppm. strength into the meter and keeping it in contact with the parts for at least 5 min.

(14) Hydrant drains are not connected to sanitary or storm sewers but are connected to dry wells or drain to the surface of the ground. Wherever practical, the hydrant drain should be plugged and arrangements made to pump out the hydrants after use.

(15) Chambers or pits containing gate valves, air relief valves, blowoffs, or other such appurtenances to a distribution system are not connected directly to any sanitary or storm sewer, and blow-offs are not connected directly to any sewer.

(16) Booster stations on the distribution system are located in rooms that have floors above ground level and are so designed and located that they will not cause a negative head in the distribution piping. In some cases it may be necessary to provide a receiving reservoir from which the water can be drawn instead of drawing suction directly from the mains.

(17) In case it is necessary to supply water from the mains of a water system that is known to be safe to some other system which is unsafe, the water is delivered through a pipe to a tank or reservoir connected to the unsafe system in accordance with the provisions of item 19 of this manual.

(18) The piping system is designed and installed to maintain a positive pressure in all its parts under normal usage at all times.

(19) The system is designed so as to afford effective circulation of water with a minimum of dead ends.

Item 25—Storage

All reservoirs and storage tanks shall be of sanitary and watertight construction and made of concrete, steel, wood, or other materials approved by the

health officer: *Provided,* That wood shall not be used for reservoirs or storage tanks located wholly or partly underground. Reservoirs and storage tanks shall be located at safe distances from sources of contamination.

Public health reason—Water which is safe and of approved quality at the source may be contaminated in storage units unless precautions are taken to prevent entry of shallow ground water, surface flood waters, or other pollution.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) Ground water storage units are watertight. When such units are made of concrete they shall be adequately reinforced to prevent development of cracks; where construction joints are necessary, adequate water stops, approved by the health officer, shall be installed. If such units are made of steel they shall be protected against corrosion. Painting [3] of steel tanks usually affords protection from corrosion for a number of years. Cathodic protection is another method used for corrosion protection of metal tanks.

(2) All such water storage units are located at satisfactory distances from sources of contamination. In ascertaining such safe distances the requirements of item 3 of this manual shall be followed.

(3) All such water storage units are equipped with watertight covers, and manhole openings in such covers comply with the requirements of item 17 of this manual.

(4) All such ground water storage units are located and protected so that there is no danger of contamination by surface drainage or flooding.

(5) Air vents in storage units are constructed of metal tubing or pipe connected so as to be watertight, and the open end of the vent is screened with 16-mesh brass or bronze screen and terminated in a downward direction by means of an elbow or equivalent means and the lower end of the outlet is not less than 12 in. above the roof of the storage unit, nor less than 24 in. above the established ground elevation.

(6) Overflows and water-level control gages are constructed so as to prevent the entrance of birds, insects, or contaminating materials, and when all openings are screened with 16-mesh brass or bronze screen and hooded or otherwise protected to prevent contaminating material from entering the opening.

(7) Overflows, blow-offs, or cleanout pipes, and drains from the roof or bottom of storage units are not directly connected to sewers.

Such pipes may discharge onto ground surface or into an open receptacle from a point at least 6 in. above the rim of the receptacle. The receptacle should be situated at ground surface and at least 50 ft. from the reservoir and may be connected to sewers.

(8) Storage units are located so that traffic will not pass over them.

(9) New reservoirs or tanks or such units which may have been contaminated or subjected to the possibility of contamination as during cleaning, alteration, painting, or repairing operations are disinfected before water from them is used for domestic consumption. The following procedure, recommended by the Minnesota De-

[3] Tentative Standard Specifications for Elevated Steel Water Tanks, Standpipes and Reservoirs. Jour. A.W.W.A., **32**: 39 (1940).

partment of Health, is suggested as a satisfactory method of disinfection:

The underside of the roof should be washed down even though it is not normally in contact with the water. Since only the floor and walls are in contact with the water these parts should be given special attention. A given amount of chlorine is more effective if applied in concentrated solution to the walls and floor of the reservoir or tank with a brush or spray than if placed in a tank full of water.

Scattering dry powdered chlorinated lime onto the walls and the floor of the reservoir when it is empty and then filling it with water to the overflow is also fairly effective. Where a chlorine solution of high concentration (100 ppm.) is used on the walls and floor, it should be rinsed off by washing down the walls and the floor with a stream of water, and this water wasted. Any adjacent valves on pipelines connected to the reservoir should be operated so as to bring the chlorine solution to all parts that come in contact with water in the pipe. When this has been done sufficient chlorinated lime should be placed in the reservoir to produce a residual of at least 1.0 ppm. at the end of a 3-hr. holding period. The reservoir should then be filled with water to the overflow. After the treated water is held in the reservoir for at least 3 hr. it may be turned into the distribution system. One ppm. for 100,000 gal. of water will require 1.25 lb. of chlorinated lime of 66 per cent available chlorine.

Reservoirs should always be disinfected after they have been altered, painted, or repaired. When the contamination is known to be limited, the disinfection may be accomplished by adding the chlorine to the reservoir full of water. The water may then be used in the distribution system.

Reservoirs may be utilized in providing large volumes of chlorinated water for the purpose of disinfecting the pipelines of the distribution system or parts of it.

For disinfecting purposes pressure tanks should be provided with an air-relief valve and an overflow on the top so that all air can be expelled from the tank and the entire surface of the interior brought into contact with water containing a high residual of chlorine.

Item 26—Protection During Construction

All public ground water supply systems which are hereafter constructed, reconstructed, or extensively altered shall be adequately protected to prevent contamination of water at the source or in the system during construction.

Public health reason—The diversion of surface water away from the source and the use of water of a safe sanitary quality during construction is essential to prevent contamination of the ground water supply.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) All surface water is properly diverted away from the source during construction.

(2) All water used for construction is obtained from a known safe source, or adequately disinfected.

Item 27—Disinfection After Construction and Repair

Underground water supplies shall always be disinfected following new construction or repair work, to remove all traces of contamination.

Public health reason—Water from newly developed ground water supplies and existing supplies which have been subjected to changes and repairs often shows an unsatisfactory sanitary quality as indicated by bacteriological examination of samples collected from the source. This is usually due to contamination from workmen, equipment, materials, or surface water which may be introduced into the ground water supply during the process of construction or repair work. While such contamination may not always be serious in itself, it obscures the meaning of the bacteriological test when present.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) All new construction and repair work is disinfected with a chlorine solution containing not less than 50 ppm. of available chlorine: *Provided,* That where minor repairs are made to existing ground water supplies and adequate treatment of the water is provided beyond the point where repairs are made, disinfection shall not be mandatory.

(2) Not less than 5 ppm. of residual chlorine is present at the source and at other representative points which have been in contact with the chlorine solution for a period of at least 3 hr., and preferably 10 hr. or longer: *Provided,* That in the case of flowing springs and flowing wells this requirement shall not be mandatory. (See appendix B, Flowing Wells and Flowing Springs.)

(3) The system is thoroughly pumped or otherwise thoroughly flushed to remove all traces of chlorine after disinfection.

(4) The results of bacteriological examination of water samples collected after disinfection and flushing of newly developed ground water supplies show that all traces of contamination have been eliminated. Such tests shall be repeated at least once after the system is shown to be clean, to check on possible regrowths.

Refer to appendix B for recommended procedure for disinfection of springs and wells.

Item 28—Bottled Waters

All bottled waters shall be so handled, from source to ultimate user, as to prevent contamination of such ground waters originally obtained from approved sources.

The provisions of this item shall not be interpreted as applying to carbonated waters, artificially prepared mineral waters, soft drinks, or similar beverages, but only to public ground water supplies, as defined in section 1, which are put into bottles or containers for the use of consumers: *Provided,* That the requirements of this item shall not be interpreted as replacing any provision of the Federal Food, Drug, and Cosmetic Act applying to beverages.

Public health reason—Contamination of originally safe ground water supplies may occur in the processes of bottling, capping, handling, and re-use of containers. Therefore, special precautions should be taken to prevent such contamination.

Satisfactory compliance—This item shall be deemed to have been satisfied when:

(1) Ground water sources used for bottling conform with the sanitation items for approved public ground water supplies given in this manual.

(2) Bottling is accomplished in a separate room equipped and used for this operation only.

(3) Bottling, capping, handling, and re-use of containers is carried out in such a manner that the final product ready for distribution in the container shall comply with the requirements of item 20 of this manual.

Specimens of bottled water collected for bacteriological analysis to determine compliance with this requirement should be taken at various places, including bottles in transit on delivery trucks, railroad cars, etc., to check on handling procedures and effectiveness of bottle washing.

APPENDIX A

Recommended Procedure for Cement Grouting of Wells for Sanitary Protection [4]

The annular space between the well casing and the well hole is one of the principal avenues through which undesirable water and pollutional matter may gain access to a well. The most satisfactory way of eliminating this hazard is to fill the annular space with cement grout. To accomplish this satisfactorily, careful attention should be given to see that:

(1) The grout mixture is properly prepared.

(2) The grout material is placed in one continuous mass.

(3) The grout material is placed upward from the bottom of the space to be grouted.

Concrete grout should be a mixture of cement, sand, and water in the proportion of 1 bag of cement (94 lb.), an equal volume of dry sand, and 5 to 6 gal. of clean water.

Neat cement grout should be a mixture of cement and water in the proportion of 1 bag of cement (94 lb.) and 5 to 6 gal. of clean water. Whenever possible, water content should be kept near the lower limit given. Hydrated lime to the extent of 10 per cent of the volume of cement may be added to make the grout mix more fluid and thereby facilitate placement by the pumping equipment. Mixing of cement or cement and hydrated lime with the water must be thorough.

Grouting procedure—The grout mixture must be placed in one continuous mass; hence, before starting the operation, sufficient materials should be on hand and other facilities available to accomplish the placement without interruption.

Restricted passages will result in clogging and failure to complete the grouting operation. The minimum clearance at any point, including couplings, should not be less than 1½ in. When grouting through the annular space, the grout pipe should not be less than 1 in. nominal diameter. As the grout moves upward, it picks up much loose material such as results from caving. Accordingly, it is desirable to waste a suitable quantity of the grout which first emerges from the drill hole.

In grouting a well so that the material moves upward, there are two general procedures that may be followed: (1) The grout pipe may be installed within the well casing, or (2) in the annular space between the casing and drill hole, when there is sufficient clearance to permit this. In the latter case, the grout pipe is installed in the annular space to within a few inches of the bottom of the annular space. The grout is pumped through this pipe, discharging into the annular space, and moving upward, around the casing pipe, finally overflowing at the ground surface. In 3 to 7 days the grout will be set, and the well can be completed and pumping started.

When the grout pipe is installed within the well casing, the casing should be supported a few inches above the bottom during grouting, to permit grout to flow into the annular space. The well casing is fitted at the bottom

[4] This information has been taken principally from a pamphlet of the Wisconsin State Board of Health, entitled: "Methods of Cement Grouting for Sanitary Protection of Wells." The subject is discussed in greater detail in that publication.

with a cap threaded to receive the grout pipe and a check valve to prevent return of grout into the casing pipe. After grout appears at the surface, the casing pipe is lowered to the bottom, grout pipe unscrewed immediately and raised a few inches. A suitable quantity of water should then be pumped through it, thereby flushing any remaining grout from it and the casing pipe. The grout pipe is then removed from the well, and 3 to 7 days are allowed for settling of the grout. The well is then cleared by drilling out the cap, check valve, plug, and grout remaining within the well.

A modification of this procedure is the use of the well casing itself to convey the grout to the annular space. The casing pipe is suspended in the drill hole and held several feet off the bottom. A "spacer" is inserted in the casing pipe. The casing pipe is then capped and connection made from it to the grout pump. The estimated quantity of grout, including a suitable allowance for filling of crevices and other voids, is then pumped into the casing pipe. The spacer moves before the grout, in turn forcing the water in the well ahead of it. Arriving at the lower casing terminal, the spacer is forced to the bottom of the drill hole, leaving sufficient clearance to permit flow of grout into the annular space and upward through it.

After the desired amount of grout has been pumped into the casing pipe, the cap is removed, and a second spacer is inserted in the casing pipe. The cap is then replaced and a measured volume of water, sufficient to fill all but a few feet of the casing pipe, is pumped into it. Thus all but a small quantity of the grout is forced from the casing pipe into the annular space. From 3 to 7 days are allowed for setting of the grout. The spacers and grout remaining in the casing and drill hole are then drilled out and the well completed.

When the annular space is to be grouted for only part of the total depth of the well, the grouting can be carried out as directed above when the well reaches the desired depth, and the well then continued below this level, within the first casing. In this type of construction, where various-sized casings "telescope" within each other, a seal should be placed at the point of transition or "telescoping" in the annular space between the two casing pipes of different diameters. The annular space for grouting between two metal casings should be not less than 1½ in. and the depth of the seal not less than 8 ft.

APPENDIX B

Recommended Procedure for Disinfection of Wells, Springs, and Appurtenances

An effective and economical method of disinfecting wells, springs, and appurtenances is by the use of calcium hypochlorite (chlorinated lime) containing approximately 25 per cent available chlorine. This material can be purchased at most drug stores and in larger quantities at chemical supply houses; a fresh supply should be used, since the chemical deteriorates on exposure to the atmosphere. If commercial preparations of high-test calcium hypochlorite containing approximately 70 per cent available chlorine are used, the required dosage will be about one-third the amount of chlorinated lime specified below.

To the amount of chlorinated lime

specified in Table 1, add small quantities of water slowly and stir until a smooth, watery paste free from lumps has been formed. Add from 5 to 20 gal. of water to the paste, and stir thoroughly from 10 to 15 min. prior to allowing the solution to settle. The clearer liquid containing the chlorine should be used, and the inert material or lime that has settled to the bottom of the container discarded. The solution should be prepared in a thoroughly cleaned utensil; the use of metal containers should be avoided, if possible, since they are corroded by strong chlorine solutions.

TABLE 1

Liquid capacity of wells or spring structures and the amounts of chlorinated lime required to provide a dosage of approximately 50 parts per million of available chlorine.

Capacity of well or spring in gallons	Chlorinated lime required, in oz.	Approximate volume of water, in gal., to be used in preparing chlorine solution
50	1.5	5
100	3.0	5
200	6.0	5
300	9.0	5
400	12.0	5
500	15.0	5
1,000	30.0	10
2,000	60.0	15
3,000	90.0	20

Where small quantities of chlorinated lime are required and a scale is not available, the material can be measured with a spoon. A moderately heaping tablespoonful of chlorinated lime, that is, with the powder about 1 inch deep in the center, weighs approximately 1 ounce.

Spring basins—(1) Wash the interior walls of the spring basin with a solution of chlorinated lime, using a stiff broom or brush to assure thorough cleaning, prior to placing the cover over the structure.

(2) Where a manhole opening is not provided in the cover, the proper amount of chlorinated lime solution should be poured into the basin and mixed with the water just before placing the cover over the structure. Care should be taken in placing the cover in position to prevent any extraneous material from entering the basin.

(3) Where a manhole is provided in the cover of the spring basin, the proper amount of chlorinated lime should be poured into the basin through the manhole opening and mixed with the water just before placing the cover over the manhole.

Shallow wells—(1) After the casing or lining is completed, proceed as outlined below before the cover platform is placed over the well.

(*a*) Remove all equipment and materials including tools, forms, platforms, etc., which will not form a permanent part of the completed structure.

(*b*) Wash the interior walls of the casing or lining with a solution of chlorinated lime, using a stiff broom or brush to assure thorough cleaning.

(*c*) Pump the water from the well until it is perfectly clear, and remove the pumping equipment that was temporarily set up for this purpose.

(2) Place the cover over the well, and pour the required amount of chlorinated lime solution into the well through the manhole or pipe sleeve opening just prior to inserting the pump cylinder and drop pipe assembly. Care should be taken to distribute the chlorine solution over as much of the surface of the water as possible to obtain proper diffusion of the chemical with the well water.

(3) Wash the exterior surface of the pump cylinder and drop pipe with the chlorinated lime solution as the assembly is being lowered into the well.

(4) After the pump has been set in position, pump water from the well until a strong odor of chlorine is noted.

(5) Allow the chlorine solution to remain in the well for not less than 10 hours.

(6) After not less than 10 hours has elapsed, the well should be flushed by pumping the water to waste to remove all traces of chlorine.

Drilled and bored wells, flowing wells, and flowing springs—(1) When the well is being tested for yield, the test pump should be operated until the well water is as clear and free from turbidity as possible.

(2) After the testing equipment has been removed, pour the required amount of chlorinated lime solution into the well slowly just prior to installing the permanent pumping equipment. Diffusion of the chemical with the well water may be facilitated by running the solution into the well through a hose or pipe line as the line is being alternately raised and lowered, and this method should be followed whenever possible.

(3) Wash the exterior surfaces of the pump cylinder and drop pipe with a chlorinated lime solution as the assembly is being lowered into the well.

(4) After the pump has been set in position, operate the pump until water discharged to waste has a distinct odor of chlorine. Repeat this procedure a few times after intervals of about 1 hr.

(5) When the chlorine solution has been completely circulated through the column of water in the well and the pumping equipment, allow the chlorine solution to remain in the well for not less than 10 hr.

(6) After not less than 10 hr. have elapsed, the well should be flushed by pumping the water to waste to remove all traces of chlorine. The pump should be operated until water discharged to waste is free from the odor of chlorine.

In the case of deep wells having a high water level, it may be necessary to resort to special methods of introducing the disinfecting agent into the well so as to insure proper diffusion of chlorine throughout the well. A method readily available is to place chlorinated lime or high test granulated calcium hypochlorite in a short section of pipe capped at both ends. A number of small holes should be drilled through each cap and one of the caps fitted with an eye to facilitate attachment of a suitable cable. The disinfecting agent is distributed by lowering and raising the pipe section throughout the depth of the water. In the case of flowing wells and flowing springs, the pipe section should be moved up and down near the bottom of the well or spring. The water moving upward through the well or spring will carry with it the disinfecting agent released at the bottom. It is impractical to maintain chlorine in flowing wells and springs for 10 hr. as specified in paragraph (5) above. Sufficient chlorine, therefore, should be applied to maintain a chlorine residual of 50 ppm. in the water flowing from the well or spring for at least 20 min. If bacteriological results on water samples collected after all traces of chlorine have disappeared indicate that the water is not safe to use, the disinfection procedure should be repeated until satisfactory results are obtained or else the

supply should be chlorinated continuously or abandoned.

Sometimes an existing well is encountered which does not respond to the usual methods of sterilization. Usually a well like this has been polluted by water which entered the well under sufficient head to cause a flow of water from the well into the water-bearing formation, carrying the pollution with it. To reach the bacteria which have thus been carried into the water-bearing formation, it is necessary to force chlorine into the formation. This may be done in a number of ways, depending on the construction of the well. In some wells, it is advisable to chlorinate the water in the well and then add a considerable volume of chlorinated water in order to force the treated water into the formation. In other wells, such as the drilled well cased with standard weight casing pipe, it is entirely practicable to chlorinate the water in the well, then cap the well and apply a head of air. By alternately applying and releasing the air, a vigorous surging effect is obtained, and chlorinated water is forced into the water-bearing formation. After treating a well in this manner it is necessary, of course, to flush it to remove the chlorine.

Should the reports on the bacteriological examination of water samples be unsatisfactory after disinfection, it would indicate that the initial treatment was ineffective. In this case, the procedure should be repeated until tests show that water samples from that portion of the system being disinfected are satisfactory from a bacteriological standpoint.

The water from the system should not be used for domestic and culinary purposes until the report on the bacteriological examination of water samples indicates that the water is safe for domestic use.

This manual has been prepared by the Public Health Service for the guidance of states, municipalities, and health districts in order to encourage a greater uniformity and a higher level of safety in the sanitary control of public ground water supplies.

The Public Health Service, in 1937, appointed a Water Sanitation Advisory Board to consider the formulation of a water supply section as a part of a general sanitation code. This Board at a number of meetings prepared some of the material necessary for a water supply section. In 1940, the Public Health Service undertook to prepare a code on ground water supplies utilizing much of the material formulated by the Sanitation Advisory Board. Several drafts of such a code were referred to the state health officers for review and comment.

Serious objections were voiced to the use of the ordinance and code form and the sentiment in general appeared to be that a manual or guide of recommended practice was preferable. This manual has been prepared with the thought of indicating desirable practice or, more correctly, minimum acceptable standards. The form followed in other Public Health Service manuals has been adopted in this manual, that is: statement of the requirement, the public health reason for the requirement, and what constitutes satisfactory compliance.

The word "shall" has been used throughout the manual to state what must be done to accomplish satisfactory compliance. Because this is a manual or guide, objection may be voiced to this terminology. However, the word "shall" has been used advisedly to permit adoption of the material without extensive editing and revision, if so desired. Where the manual is used as a guide in the preparation of other regulations or is revised to suit the needs of a particular health authority no harm will result from the use of the word "shall" throughout in this manual.

This manual will be subject to periodic review and revision for incorporation of such changes as will increase its usefulness.

Federal Fair Labor Standards Act and Water Companies

THE Federal Fair Labor Standards Act of 1938 requires the payment of wages or salaries at one and one-half the regular rate of pay for all hours worked in excess of forty hours in a week by an employee whose work is in interstate commerce or in an occupation necessary for the production of goods for interstate commerce.

The Wage and Hour Division of the Department of Labor in April 1942, issued an interpretative memorandum (R-1789) upon the subject, insofar as the law was applicable to employees of public utility service organizations—water, gas, electricity, etc.:

"It is the position of the Wage and Hour Division that the Act is applicable to employees engaged in producing fuel, power, or other goods or facilities for use or consumption entirely within the State by essential instrumentalities of interstate commerce, when such use or consumption aids or facilitates the interstate activities performed by means of such instrumentalities. Thus, for example, the Act is applicable to employees engaged in producing electric energy, steam, fuel or water for use within the State by railway terminals or depots, telephone exchanges, radio broadcasting stations, etc. The activities of such employees directly facilitate, aid, and contribute to interstate transportation, transmission and communication, as a result of which such employees in our opinion are themselves properly deemed 'engaged in commerce.'

"There are cases, moreover, where employees producing goods for use entirely within the State of production can be said to be engaged in a 'process or occupation necessary to the production' of other goods which move out of the State of production and are, therefore, subject to the Act. It is our opinion, for example, that the Act applies to employees engaged in producing fuel, power or water, which are used or consumed entirely within the State in the production of other goods for interstate commerce, and in accordance with this principle, the Act is applicable typically to employees engaged in producing power or water, all of which is locally consumed, but some of which is sold to local manufacturers and consumed by them within the State in the production of other goods for interstate commerce."

There was in January 1944, a decision handed down in Missouri resulting from action brought by a group of employees of the St. Joseph Water Co. (a Missouri Corporation). The finding of the Supreme Court of Missouri in this case contains an interesting analysis of the nature of the public water supply business as well as the applicability of the terms of the Act in question to the employees of water companies.

Since within recent months certain water companies have appeared to be unaware of the possible application of this law to their dealings with employees, the Missouri decision is published herewith.

A decision handed down by the Supreme Court of Missouri. Text made available by John H. Murdoch, Jr., Pres., Pennsylvania Water Works Assn., Harrisburg, Pa.

Its publication is intended to be a matter of information only. No opinions concerning the applicability of the Act to any other water company are expressed or implied. The study of the decision will indicate to any owner or executive the possible relation of his operations and his employees to the terms of the Act, and will, if he deems it proper, lead him to review the subject with his own legal counsel.

HARRY E. JORDAN,
Secretary A.W.W.A.

Supreme Court of Missouri

(*Division Number One—September Term, 1943—January Call, 1944*)

William W. Fountain *et al* (*Employees*) v. St. Joseph Water Co. (*Corporation*) — No. 38,745

Judge Laurence M. Hyde delivered the decision.

This is an action under the Fair Labor Standards Act of 1938 (U.S.C.A., Title 29, Chap. 8, Secs. 201–219.) to recover overtime compensation, liquidated damages and attorney's fees. (Sec. 216.) The court found for defendant on the ground "that defendant is a retail or service establishment the greater part of whose selling or servicing is in intrastate commerce within the meaning of Sec. 13(a)(2)" of the Act (29 U.S.C.A. 213(a)(2). Plaintiffs have appealed. Our jurisdiction is invoked because of the amount involved.

The parties agreed upon most of the facts but some evidence was offered by each. Plaintiffs claim that they are entitled to judgment as a matter of law under the facts. Defendant is incorporated under the laws of Missouri, furnishes and sells water only in the counties of Andrew and Buchanan and all of its plants, pipelines and installations are located therein. Likewise, all of the work of its employees is performed in these counties. It takes water from the Missouri River, pumps it into settling basins where it is filtered, purified and sterilized. The water is then pumped into holding basins from which it flows by gravity into water mains to its customers, mainly in the city of St. Joseph. Defendant's mains are connected with the premises of each customer by a service pipe owned and installed by the owner of the premises. Defendant also furnishes standby fire pressure service, tests and repairs hydrants and valves, and inspects pumbing fixtures of customers. Defendant's rates and business are regulated by the Missouri Public Service Commission.

St. Joseph has about 75,000 inhabitants. It has industries engaged in producing goods for shipment in interstate commerce such as Swift & Co., Armour & Co., Quaker Oats Co., Goetz Brewing Co., Western Dairy and Ice Cream Co., Douglas Candy Co. and others engaged in bottling soft drinks,

making vinegar and manufacturing chemicals. There are also six railroads through the city to which defendant furnishes water. Some of this is used to fill boilers of locomotives and drinking water tanks and other tanks on cars. The city is about seven miles long and three miles wide. Most of the defendant's pipe mileage is in the residential sections. During the period involved herein it had from 18,330 to 19,007 total customers. Domestic customers (single private homes) were from 14,535 to 15,106, paying an average of less than $1.50 per month. Commercial customers (including apartment and boarding houses, two or more family homes, churches, hospitals and hotels, as well as wholesale and retail commercial establishments) were from 3,446 to 3,520, paying an average of less than $4.00 per month. Municipal customers (city and county) were 89 to 108, with an additional 120 to 123 fire service customers (not including municipal fire hydrants rented on a different basis) to service fire sprinkler heads, both public and private. Industrial customers were from 103 to 149 and other public utilities from 37 to 38. Industrial and other public utility users consumed 24.6 per cent of the total volume of water and produced 12.4 per cent of defendant's total revenue.

Industrial plants made various uses of the water purchased. Swift & Co. had their own wells and used water from them in their canning, curing and processing departments. It used defendant's water mainly for washing live stock for slaughter and other cleaning purposes. Goetz Brewing Co. used it as an ingredient of its beer as well as for drinking water and cleaning purposes. Quaker Oats Co. used it at one plant only for drinking and cleaning purposes and in another plant as an ingredient in manufactured food products. Bottling companies used it as an ingredient of carbonated beverages. It was used by another company as an ingredient of vinegar. It was likewise used by chemical and pharmacal companies in their products. It was also used to fill boilers in factories using steam power plants.

Plaintiff's work ranged from repairing mains, hydrants, meters and valves, inspecting plumbing, checking and testing the distribution system, and laying new mains, pipes and meters, to reading meters, collecting delinquent accounts, answering telephone calls and doing janitor or clerical work. Some of them worked on the reservoirs, washing, repairing and breaking ice in them. It was not shown that any one of them had ever directly connected or serviced the appliances through which water immediately flowed into the private water pipes of any industrial or public utility users as a part of his regular work or otherwise.

Plaintiffs say that "their work in producing and distributing usable water to the numerous industries in and around St. Joseph is a 'process or occupation necessary to the production' of 'goods for commerce,' as this quoted language is defined and used in Secs. 203 and 207." (See definition of "produced," Sec. 203j.) Of course, whether or not water sold by defendant is necessary to the production of other goods would not make any difference if deferment is exempted from the application of the Act under the provisions of Sec. 213. Plaintiffs say that defendant is not a "retail or service establishment" because it is a public utility and if it falls into any other classification it is a manufacturer. Defendant raises no issue as to the form of

action, or constitutional grounds, so that the question for our decision is the interpretation and application of provisions of the Act. Thus we are not called upon to consider herein what Congress could do in this field but only to determine what it has done therein in this Act. The purposes of the Act were discussed, and its constitutionality settled, in *United States* v. *Darby Lumber Co.,* 312 U.S. 100, 61 S.Ct. 451, 85 L.Ed. 609. It is also settled that "the provisions of the Act expressly make its application dependent upon the character of the employee's activity," rather than upon the general interstate or intrastate nature of the employer's business. (*Kirschbaum* v. *Walling,* 316 U.S. 517, 62 S.Ct. 1116, 86 L.Ed. 1638.)

The basis of the Act is the Commerce Clause of the Constitution of the United States. However, the United States Supreme Court has called attention to the fact that "Congress did not exercise in this Act the full scope of the commerce power"; that it did not intend that it be "extended to business or transactions 'affecting commerce'" only; and that it "plainly indicated its purpose to leave local business to the protection of the states." (*Walling* v. *Jacksonville Paper Co.,* 317 U.S. 564, 63 S.Ct. 332, 87 L.Ed. 393; see also *Higgins* v. *Carr Bros. Co.,* 317 U.S. 572, 63 S.Ct. 337, 87 L.Ed. 398.) The exemption in Sec. 213(a)(2) of "any employee engaged in any retail or service establishment the greater part of whose selling or servicing is in intrastate commerce" (relied upon by the trial court) and that in Sec. 213(a)(1) of "any employee employed in a bona fide . . . local retailing capacity" as well as other provisions of the Act clearly so indicate. In the Jacksonville Paper Co. case, the Supreme Court said of these exemptions: "It is quite clear that the exemption in Sec. 13(a)(2) was added to eliminate those retailers located near the state lines and making some interstate sales. . . . And the exemption for retailers contained in Sec. 13(a)(1) was to allay the fears of those who felt that a retailer purchasing goods from without the state might otherwise be included." The Supreme Court held therein that employees, of even a wholesaler doing considerable interstate business, were not under the Act if their own work was only in the intrastate phases of the business. The same ruling was made by the Supreme Court in the Carr Bros. Co. case. The court reaffirmed the test that "the applicability of the Act is dependent upon the character of the employee's work." Surely employees engaged in local selling, entirely within one state, of a commodity acquired in that same state, were not intended to be within the Act.

We think the trial court was right in holding that these exemptions applied to defendant herein. In *White Motor Co.* v. *Littleton* (U.S.C.C.A. 5th Cir.) 124 Fed. 2d,92, the Court said: "The word *retail* is not defined by the Act. Given its common and ordinary acceptation when used in sales parlance, it means a sale in small quantity or direct to the consumer, as distinguished from the word wholesale, meaning a sale in large quantity to one who intends to resell. *The character of the sale is not altered by the use to which* the consumer may put the purchased commodity." (Our italics.) The same court in *Collins* v. *Kidd Dairy & Ice Co.* (U.S.C.C.A. 5th Cir.) 132 Fed. 2d, 79 said: "A retail establishment under Sec. 13(a)(2) is one that sells goods in small quantities for profit, and a manufacturer engaged primarily in the production of goods does not come

within the terms of the exemption." It held, as to the ice company therein involved (selling ice in two states), that: "though its business consisted in part of wholesale and retail sales, it was predominantly a manufacturing establishment." We think the distinction applicable here (between an ice manufacturer and a water company) is pointed out in *Samuels* v. *Houston* (D.C.) 46 Fed. Supp. 364 (also holding that such an ice company was a manufacturer and therefore not within the exemption of a retail establishment) namely, that: "processing incidental to retail selling will not alter the retail character of the business." The court said: "A custom tailor making clothes to order may be engaged in manufacturing while his neighbor, a haberdasher, selling custom-made clothes and altering them to suit the customer may be a retailer. The distinction between incidental processing and actual manufacture is quite real, though often one of degree." Defendant herein sells only water. It certainly does not manufacture this water. It finds it in the Missouri River, pumps it to settling basins and there (at most) merely processes it by filtering, purifying and sterilizing it. When it is sold, it is still the water that came out of the Missouri River even though it has been purified by taking out some foreign substances and sterilized by adding chemical elements. Our conclusion is that defendant is not a manufacturer of water, but is a retailer thereof.

Plaintiffs say that this exemption should not apply to a public utility, citing *Schmidt* v. *Peoples Telephone Union* (U.S.C.C.A. 8th Cir.) 138 Fed. 2d,13. However, not only was the telephone company therein involved handling interstate calls, but also as pointed out in that opinion the Act contains a separate exemption for telephone companies with classification according to number of stations. We see nothing in the Act to prevent the exemption from applying to a public utility which is a retail establishment. Defendant is a public utility because it sells a commodity essential to modern municipal existence in which the public has an interest because it is vital to public health and safety, but it, nevertheless, sells it at retail.

Certainly all of the defendant's sales are "direct to the consumer" and the bulk of them are in small quantity. None of them are made "to one who intends to resell" the water, and none of them are made outside this state. In this connection we note that the definition of "goods" (Sec. 203i) specifically provides that it "does not include goods after their delivery into the actual physical possession of the ultimate consumer thereof other than a producer, manufacturer or processor thereof." Certainly the water sold by defendant is delivered "into the actual physical possession of the ultimate consumer" and is thus consumed by him, even if used in manufacturing foods or beverages with considerable water content. Surely, it could not be reasonably claimed that making beer, vinegar or coca cola (or converting water into steam) is producing, manufacturing or processing water. Such products are not sold as water as defendant sells it. Plaintiffs argue that defendant cannot be a retailer because it does not buy what it sells. However, we think the determining factor here is the character of its selling and not the manner of acquisition of what it sells. (See *Great Alantic & Pacific Tea Co.* v. *Cream of Wheat Co.* (U.S.C.C.A. 2d Cir.) 227 Fed. 46). The fact that the defendant sells water through the

instrumentality of connecting pipes and meters does not prevent defendant's business from being retail. (See *Walling* v. *Sanders* (U.S.C.C.A. 6th Cir.) 136 Fed. 2d, 78, so holding in case of vending machines; see also *White* v. *Jacobs Pharmacy Co.* (D.C.) 47 Fed. Supp. 298 (chain stores); *Zeahing* v. *Brown Materials Ltd.* 48 Fed. Supp. 740 (sand, gravel and other building materials); see also discussion in *Brown* v. *Minngas Co.* (D.C.) 51 Fed. Supp. 363 (gas company which sold gas outside state and did much wholesale business).) We, therefore, rule that the trial court correctly held defendant to be within the exemption of a retail establishment. (As to defendant being a service establishment, it seems to us that such servicing as it did was only incidental to its main business of selling water.)

Furthermore, whether or not defendant is within this exemption, we think that the activities of its employees in connection with its business of taking, processing and selling water, so far as the evidence discloses them, were too remote from "the production of goods for commerce" to bring them within the Act. Employees were much more immediately and directly connected with the production of goods for commerce, in the two cases recently decided by the United States Supreme Court upon which plaintiffs most strongly rely. (*Kirschbaum Co.* v. *Walling,* 316 U.S. 517, 62 S.Ct. 1116, 86 L.Ed. 1638; *Warren-Bradshaw Drilling Co.* v. *Hall,* 317 U.S. 88, 63 S.Ct. 125, 87 L.Ed. 99.) In the Kirschbaum case, they serviced the building in which such goods were produced, even actually transporting such goods (by operating elevators) on their way out of the building into such commerce after they were made, as well as thus bringing in the materials from which they were made. In the Warren-Bradshaw case, they operated the drilling equipment necessary to reach the oil (intended for interstate commerce) and to provide the means by which it could be taken from the ground.

In the Kirschbaum case, the court ruled that each case must be decided upon the specific factual situation involved, saying: "what is needed is something of that common sense accommodation of judgment to kaleidoscopic situations which characterizes the law in its treatment of problems of causation." This, of course, is the test of direct or remote connection. The court also applied a rule similar to that developed in determining the application of the Federal Employers' Liability Act, saying: "the work of the employees in these cases had such a close and immediate tie with the process of production for commerce, . . . was therefore so much an essential part of it, that the employees are to be regarded as engaged in an occupation 'necessary to the production of goods for commerce.'" (See also *Overstreet* v. *North Shore Corp.,* 318 U.S. 125, 63 S.Ct. 494, 87 L.Ed. 423; *McLeod* v. *Threlkeld,* 319 U.S. 491, 63 S.Ct. 1248, 87 L.Ed. 1154; where this test is further considered.) The Court discussed the application of such rules in Kirschbaum case, as follows: "Because some employees may not be within the Act even though their activities are in an ultimate sense 'necessary' to the production of goods for commerce, it does not follow that no employees whose activities are 'necessary' are entitled to the benefits of the Act. . . . 'Necessary' is colored by the context not only of the terms of this legislation but of its implications in the relation

between state and national authority. We cannot, in construing the word 'necessary,' escape an inquiry into the relationship of the particular employees to the production of goods for commerce. If the work of the employees has only the most tenuous relation to, and is not in any fitting sense 'necessary' to, the production, it is immaterial that their activities would be substantially the same if the employees worked directly for the producers of goods for commerce."

The Supreme Court of Arkansas in *Couch* v. *Ward,* 168 S.W. (2d) 822, recently applied these tests in holding that the Act did not apply to an employee of a small ice plant which sold only 1.3 per cent of its ice to interstate carriers for use in refrigerator cars and trucks. The Court said: "While it may savor of 'the simple and familiar dialectic of suggesting doubtful and extreme cases,' which has been condemned, we cannot believe that the man who produces waste or lubricating oil which is eventually sold to lubricate the axles of a railway car, *or the employees of a local water company which sells water for locomotives, are to be regarded as producing goods for interstate commerce within the meaning of this Act.* A manufacturer of paint would not be held to be producing goods for interstate commerce solely because he sold 1.3 per cent of his product to a railroad company and that company used the paint to paint refrigerator cars. To use the language of causation, the connection with interstate commerce is too remote." (Our italics.) We think that plaintiffs' work here was still more remote from the production of goods for commerce than that shown in the ice cases. The actual ice produced did move in such commerce (to preserve perishable goods during transportation therein) in the final form in which it left the plant. (See *Chapman* v. *Home Ice Co.* (U.S.C.C.A. 6th Cir.) 136 Fed. 2d 353, where the Court held the Act applicable to an ice manufacturer which sold a more substantial portion of its production for such purposes to interstate carriers.) This was not true of the water sold by defendant. It was either completely consumed or used by being mixed into some other products which were not sold as water. In making beer (or vinegar, soft drinks, etc.) it was at least merged into a product which was marketable only because of the ingredients it contained other than water. The water used in railroad engines had to be converted into steam to be of any use in transportation. What portion of defendant's total sales was so used does not appear, but it is evident that it would be very small. Therefore, upon the tests established by the United States Supreme Court, our conclusion is that plaintiffs' connection with the production of goods for commerce was too remote and tenuous to bring them within the Act; and that their work for defendant cannot reasonably be said to be so closely connected with such production as to be practically or essentially a part of it.

Safety in Water Main Construction

By Fred Eitel

SAFETY in water main construction can be separated into three different heads: (1) safety of the workmen during construction; (2) safety to the consumers by providing them with a safe, pure and potable product; and (3) safety of materials.

The slogan "Safety First," was popularized some 30 yr. ago. Before that time not much thought had been given to the safety of the individual workman, but managers began to realize that a tremendous economic waste was taking place through personal injuries. Engineers began to make a study of safety measures and the safety engineer, whose sole duty it was to look after this one item, became an important member in every manufacturing or construction organization. The wisdom of this has been amply proved in the reduced insurance rate. In these days of workmen's compensation, managers and other supervisory officials in every organization give great thought to the safety of their employees. The American Water Works Association immediately took up the idea of safety first and today safety precautions are given "AAA" priorities in even the smallest construction or repair job.

A paper presented on February 10, 1944, at the winter meeting of the New Jersey Section, Newark, N.J., by Fred Eitel, Asst. Supt., Newark Div. of Water, Newark, N.J.

In the city of Newark (population 450,000), safety in the construction of even a simple trench will depend very largely on the different soil conditions encountered. These soil conditions vary, in Newark, from marsh land, having an elevation of only 10 ft. above mean low water, to shale rock, having an elevation of over 200 ft. above mean low water. In the low or marsh area of the city (namely, the Port Newark and Newark Airport regions) an attempt is seldom made to lay a main unless the entire trench is close-sheathed and considerable lateral bracing is used to withstand the terrific pressure of shifting sand and water. Tidal waters must also be contended with in these areas. There is an average tidal rise and fall of 6 ft. and, since an attempt is made to keep a minimum cover of 4 ft. over all mains, one can readily see the importance of tight sheathing. In the construction crews it is the sole duty of the assistant foreman to insure the safety of men in the trench by supervising the sheathing and bracing work. Further north, the geological formation of the ground changes from meadow muck and sand to densely packed sand and gravel and then to a gravel and clay formation. This particular formation gives the most trouble, because in dry weather the sides of the trench stand firm and the vigilance of the foreman relaxes. Consequently,

the tendency is to sheath and brace as little as possible. With shower or prolonged rain the gravel suddenly starts to slide and the whole trench caves in. It is necessary to impress on foremen the danger of taking chances and to brace the trench to withstand the most severe conditions. In the Forest Hill and Roseville sections of the city there is hard shale rock in some places only 1 ft. below the surface of pavement.

Sheathing Important

In these two areas sheathing is hardly necessary when laying small distribution mains or services, but when laying large feeder mains along an established gradient, sheathing becomes a very important item because of the great depth of the trench. The laying of a 48-in. main, whose cover varied from 4 ft. at its highest point to over 30 ft. at its lowest point, has recently been completed. This contract was performed by WPA under the supervision of the Newark Water Department. Particular care was taken to insure the safety of the WPA laborers working in the trench, especially in the deep cuts. All excavation was done by hand, the laborers loading 1-cu.ft. buckets in the trench and having them raised to the street surface by crane. Throughout the Roseville section of the city it was necessary to blast out the rock during the course of construction. Here again, every precaution was taken to protect the men. Wire mats weighing 2 tons each were placed over the charges and all men were cleared out within 200 ft. of the blast before the detonator was set off. The blasted material was then loaded into the buckets by hand labor. As the operator of the crane could not see into the trench it was necessary to appoint a signalman to direct him. Safety precautions were taken in that the signalman was instructed in the use of the standard hand signals as adopted by the AFL Hoisting Engineer's Local. As the crane operators were all supplied by this local, there was no mixup in the use of hand signals. The signalman, of course, had no duties other than directing the crane operator. Consequently, this contract, over 3 mi. in length, was completed without a single accident.

Preparation and Storage of Pipe

The preparation, coating and storage of cast-iron pipe merits description here. Pipe is purchased direct from the foundry and delivered to storage yards in carload lots. The pipe is foundry dipped only. The cars of pipe are unloaded by crane and the pipe is piled in pyramid form—each length being chocked and each tier separated by a 2 x 10-in. wood plank to prevent slippage, which might result in injuries to the workmen. Pipe is moved to the lining machine rack by crane and then to the liner by hand labor as it is needed. The lining machine is simply a set of rollers operated by a belt connected to a motor. The pipe is placed on these rollers, the hot enamel is poured into the bell and spigot ends of the pipe; the bulkheads are closed and the pipe revolved at about 100 rpm. until the enamel hardens. It is very important to keep the enamel at the correct temperature (between 475°–500°F.), because if the temperature falls below 475°F. the enamel will congeal and will not give a uniformly smooth surface. If the temperature increases above 500°F., the oil and tar will separate and the enamel will check and will not adhere to the walls of the pipe. The workmen operating the lining machine are

equipped with suction type goggles, nasal masks and canvas gloves to prevent any injury caused by flying tar fragments, inhalation of sulfur fumes and heat. After the pipe has been lined it is transported to the job site by truck and laid along the street side of the trench, bell end to spigot end where, until it is used, it serves as a barricade. While pouring the lead joints every precaution is taken to prevent injuries to the workmen. Kerosene is added to the joint before the lead is poured to absorb any moisture that may have gathered in the joint, thus preventing a possible "lead flash."

Line Sterilized

After the main is laid and the trench backfilled, the line is sterilized, under the supervision of the city chemist. Either chloride of lime in powder form (mixed with water in a drum and allowed to trickle into the main as it is being filled) or liquid chlorine (applied by a portable chlorinator) is used for this purpose. After 24 hr. the main is thoroughly flushed and samples of the water are taken to the laboratory where an examination is made. If the coliform bacteria content is negative, the main is passed by the chemist and the line is placed under pressure as part of the distribution system. But if the results are positive, the main is rejected and must be pumped dry and re-chlorinated. Every precaution is taken during the chlorination process to prevent the operator from being overcome by chlorine fumes. The operator is equipped with rubber gloves and an oxygen mask and is given strict instructions to test all connections on the chlorinator and main to discover possible leaks.

Every possible precaution is taken to insure the consumer a pure, potable water from the time the water leaves the intake at the watershed, thence through the transmission lines to the equalizing reservoirs, thence through the feeder mains to the distribution systems.

Periodic Inspection

In connection with safety and preservation of materials, it may be noted that some of the city's steel transmission and cast-iron feeder mains have been in continuous service for over 50 yr. These lines have developed small leaks and periodic inspections have shown that the interiors of the lines were badly tuberculated. Rather than re-lay these lines the city decided to clean and reline them with a cement lining, thereby increasing their useful life as well as their carrying capacity. This work was started 8 yr. ago and is still being done.* In the case of one 36-in. steel-riveted pipe, even though the diameter of the pipe was reduced by $\frac{1}{2}$ in. by the application of the cement lining, the increased capacity of the newly-lined pipe over the old pipe was 40 per cent and the coefficient was as good as, if not better than, when the pipe was new. Further evidence of the attempt of the city of Newark to preserve existing mains was demonstrated in the lining of all mains in the Port Newark areas. A 16-in. cast-iron main, laid on Doremus Avenue in 1922, began to spring numerous small leaks. These leaks seemed to disappear when the pressure in the main was reduced by means of pressure regulators.

Then in 1938, the Fire Underwriters started to complain about the dangerous fire hazard, this being the gasoline

* "Rehabilitation of Mains in Newark, New Jersey." Jour. A.W.W.A., **28**: 1348 (1936).

storage area for the metropolitan New York district. Upon investigation, the main was found to be badly pitted owing to the acidic condition of the ground. The pipe had softened so much that it was possible to cut bits of metal from the side with an ordinary penknife blade. A test was made to find some way to neutralize the acid. The result was a 4-in. protective coating of 1 : 3 : 10 lime cement mortar. The 16-in. main was relaid with a 20-in. pipe and all mains in this area were uncovered, tested and encased with the above mortar. The pressure was then increased to a normal 55 lb. and there has been no trouble since. This work was done by the WPA during the years 1940 and 1941. To insure the preservation of metal and the protection of property owners from further damage by water, there are periodic inspections of hydrants, flow tests, pitometer tests and, just recently, leakage surveys. Any parts of hydrants, valves, regulators, etc., found to be worn are replaced and all packing glands repacked to prevent leakage. For the leakage survey the Fisher Leak Locater and the comparatively new Universal Leak Detector are used. With these machines it is possible to detect small leaks before they appear on the surface and start causing damage by flooding cellars, duct lines, telephone lines, etc. Small joint leaks which, if undetected, may blow at a later date causing severe damage by water, are soon located with these machines and section crews make the necessary repairs. These section crews (three in number) are carried to the scene of the leak in fully-equipped trucks. Each crew is made up of a foreman, a chauffeur, two repairmen and four laborers. The repair or section truck is radio equipped and is always in communication with the operating office. These trucks are fully equipped with different-sized operating keys, shut-off keys, repair parts for valves, hydrants, etc. Each truck contains a complete first aid kit. The foreman is capable of treating any minor injury.

The city of Newark Water Department has given every consideration, not only to the safety of its employees and consumers, but also to the preservation of materials now made scarce by wartime restrictions.

Stop Waste—Look After Your Pumps

By Morris L. Hicks

IN localities in which some water systems operate, there is a shortage of electric generating capacity. In all localities, however, power means the burning of fuel in the form of coal, fuel oil or diesel oil. These fuels and facilities for transporting them are scarce and will continue to be so for the duration. Even though an operator may be located next to a large hydro-electric generating plant, a saving in power will still represent a saving in fuel because all of the water power available will be used and the excess required by the public will be generated by burning fuel. If an operator generates his own power, the problem is the same. Every purchaser of a new pump thinks at least twice before making such a capital expenditure. How often is the fact considered that the *user pays out in power bills the equal of the cost of the pump every 30 to 90 days,* depending on the use factor, power cost, design conditions of the unit and the efficiency of operation and maintenance? Efforts to save power will, therefore, not only represent a saving of vital fuel and transportation facilities, but also reduce power costs. New pumping equipment is only available at the present time on priority ratings. Suggested alternatives to complete replacement may help to reduce power consumption.

The principal parts affecting the efficiency of a pump are the volute, the impeller and the wearing rings. Neither the volute nor the impeller are subject to rapid wear. They should be inspected and cleaned every time the pump is disassembled—certainly once a year. Should anything become lodged in the impeller or volute between inspections, it will be evident by reduced capacity and possibly by vibration of the rotating element.

A point of hidden waste is in the joint dividing the pressure side of the pump from the suction side. One side of this joint is stationary and the other side is rotating with the impeller. This joint forms a path of leakage of water already pumped back into the suction side from which it must be repumped. Such leakage may amount to from 3 to 15 per cent of the total capacity of the unit, which means 3 to 15 per cent of the power expended to drive the pump is wasted because of this joint. For many years it has been the practice of most manufacturers to protect the case and impeller from wear at these joints by the use of wearing rings, one on the impeller (wheel ring) joining or meshing with one (case ring) on the case (Figs. 1, 2, 3).

A paper presented on October 16, 1943, at the Four States Section Meeting, Philadelphia, Pa., by Morris L. Hicks, Dravo Corp., Philadelphia, Pa.

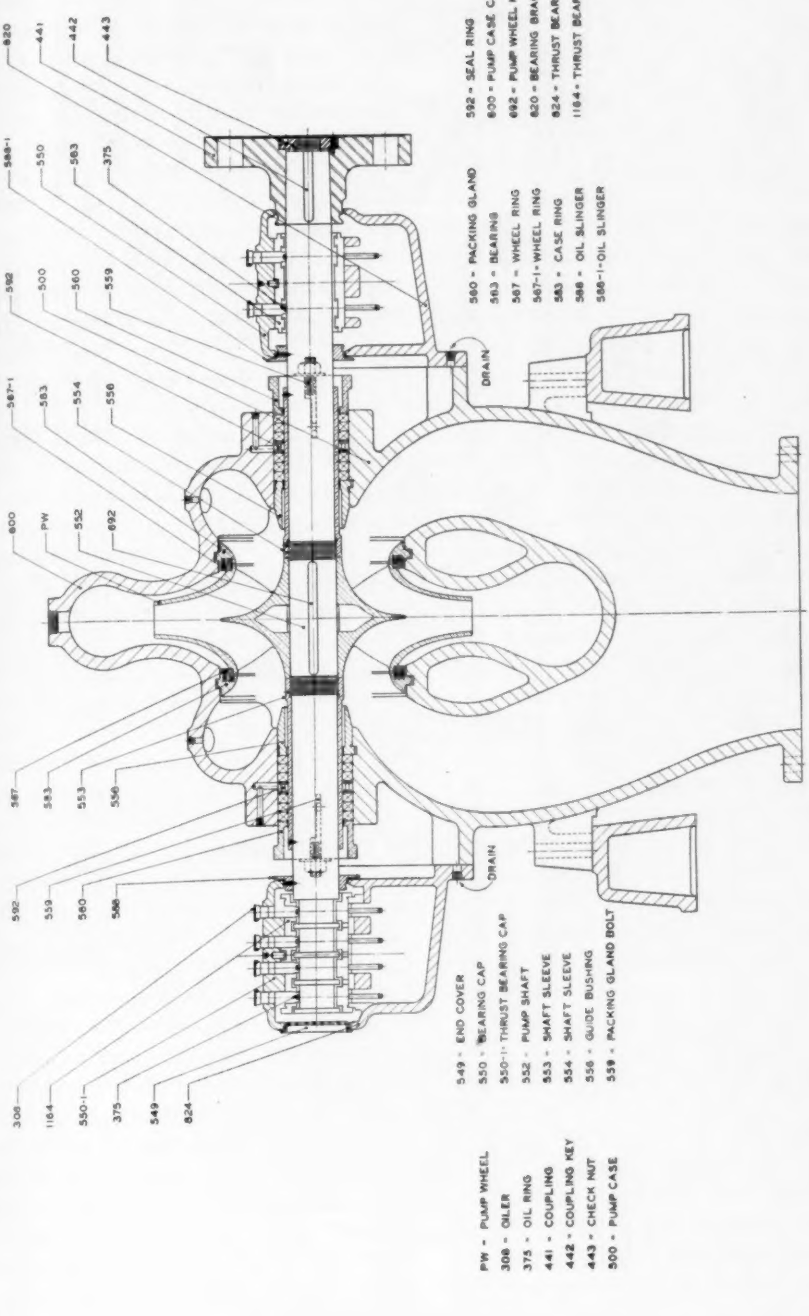
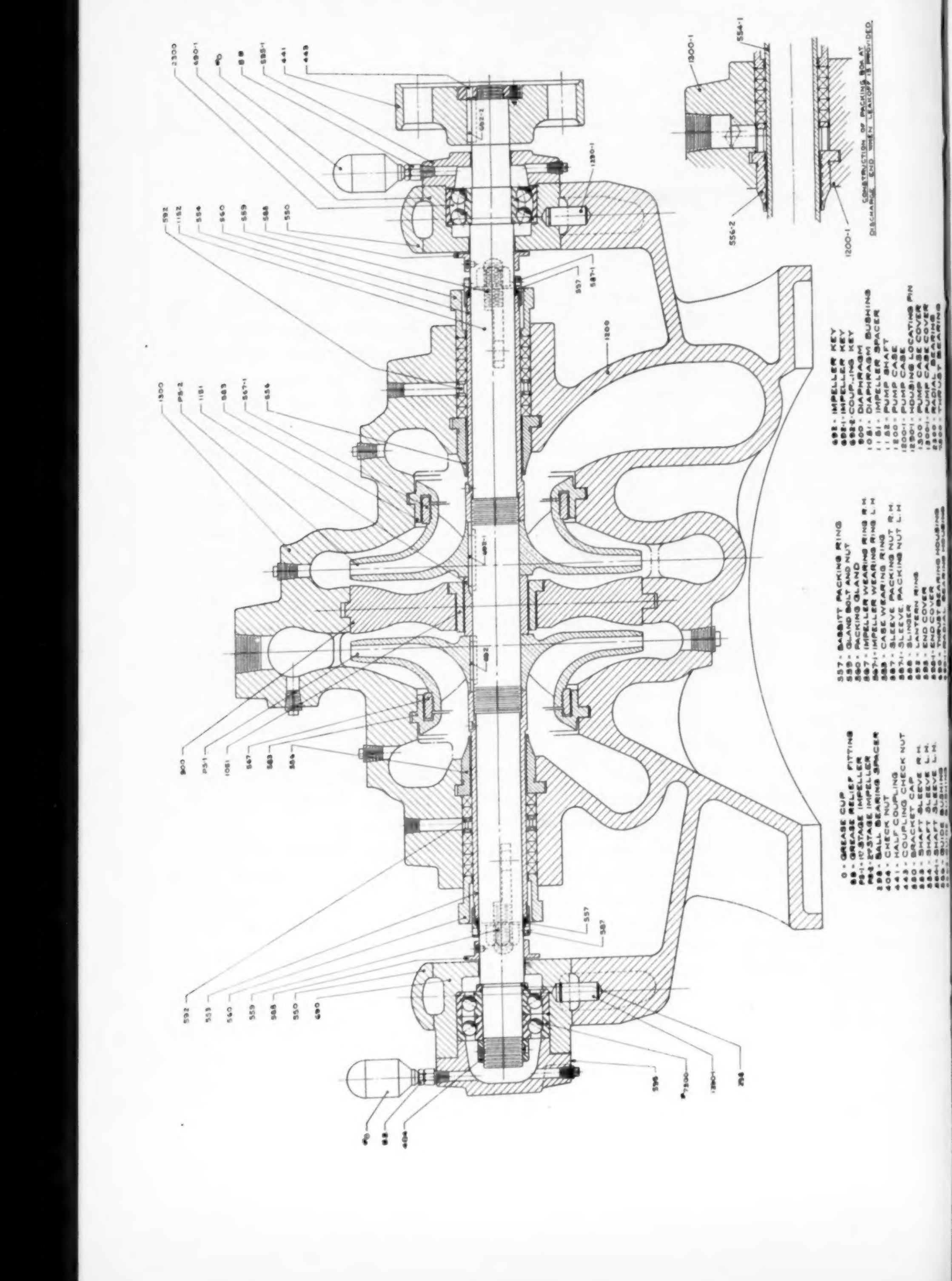


FIG. 1. Assembly of Double Suction Pump



The wash of leakage through this joint causes wear, which in turn causes increased leakage and power waste. Operators should ask the manufacturer of pumping equipment to give them the designed clearance between the rings. The rings should be replaced when they show an increase of from 25 to 50 per cent over their design clearance, depending upon the type of rings used. This very small expenditure will go a long way toward restoring a pump to its original efficiency and capacity if the other parts are in good condition.

Anything which can be done to reduce the total head against which pumps must operate is a step in the right direction. Pipe cleaning, the use of standby pipelines, or reduction of pressure where conditions permit should be investigated.

In purchasing pumping equipment most operators, for safety, add about 10 per cent, or perhaps more, to the estimated head at which the units will have to work. After the equipment is installed and operating, however, the actual head required to deliver the necessary quantity, can very easily be determined.

Here is a typical case which can be duplicated in a great many plants: A water works needed a 10-mgd. unit and calculated that it should be designed for a total head of 185 ft. To be on the safe side the water works specified 200 ft. to the manufacturer —about 8 per cent over the estimate. After the installation was completed a test was run, throttling the discharge gate valve to the design capacity and measuring the head on the downstream side of this valve. (The operator made sure to add the suction lift, velocity head and an allowance for the head loss through the check valve). The

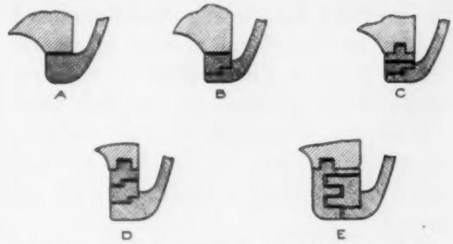


FIG. 3. Various Types of Wearing Rings

results of this test indicated that the actual total head should be 180 ft. The manufacturer of the pump then recommended that the impeller diameter be reduced slightly. The results are shown graphically in Fig. 4.

The more water pumped through a given line in a given time, the higher the power costs, due to increased friction head. This friction head varies approximately as the square of the rate of flow. Some operator might devise a scheme whereby one pump is kept for maximum requirements and another unit reduced for average load. Such matters require very careful study and it is impractical to generalize on any particular case.

If generating capacity is critical in an area or, if the matter is considered solely from the amount of power bills, thought should be given to pumping at off-peak hours. This should be reviewed with a representative of the power company with due consideration to storage capacity and sudden demands for water.

There is also a great opportunity for power saving in the prime mover.

If pumping equipment is steam-turbine driven, it is suggested that the engineer investigate the steam pressure drop across the governor valve. This should not exceed 5 per cent of the throttle pressure and in many instances can be kept well below 5 per cent. If this drop proves to be excessive, it can

be lowered by closing hand-operated valves on individual nozzles or nozzle sections which admit steam to the first stage of the turbine. If no such hand valves are available on the turbine, they can probably be installed by consultation with the manufacturer of the unit.

If a turbine has more than one pressure stage, the leakage area between the diaphragm and the shaft should be checked against the original clearance and the bushings and sleeve which protect this joint replaced if the wear has

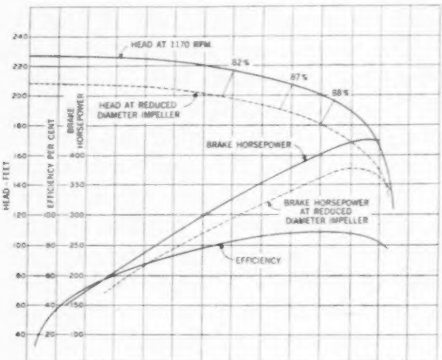


FIG. 4. Results of Test to Determine Needed Head

increased from 25 to 50 per cent. The condition of the turbine buckets, guide bushings and nozzles should be carefully inspected at least once a year, and these parts should be cleaned, if necessary. It is also very important that the turbine nozzles and guide bushings line up properly with their respective wheels and that the clearance between these parts is in accordance with the manufacturer's recommendations.

When it is considered that a turbine designed to operate at 28 in. (Hg) vacuum will require approximately 8 per cent more steam to carry the same load if the vacuum drops to 27 in., the importance of a clean condenser, adequate vacuum pumps and a dependable supply of circulating water is realized.

There are great possibilities for fuel saving in the power plant that is generating the steam for a turbine; these possibilities should not be overlooked.

If an operator is driving pumping equipment with an electric motor, he should determine the actual voltage at the motor terminals and check it against the name-plate reading. If there is serious disagreement, he may be able to compensate for this by adjustment of the voltage taps on the transformer. Operating at lower or higher voltages can be the cause of serious inefficiency.

While it will not necessarily lead to power saving, it is also suggested that the operator check the resistance of the insulation on the motor to be sure that it is adequate for the voltage which he is using. This will go a long way toward prolonging the life of the motor and avoiding costly shut-downs.

If the prime mover is a diesel engine, it should operate, if in good condition, at a certain definite exhaust temperature for a given load. This temperature may be stamped on the engine name plate or it can be obtained from the manufacturer. If it is operating with an exhaust temperature higher than this, the operator should start looking for trouble in the form of low fuel pressure or air pressure, sticky or leaky valves, carbon deposits or other sources of trouble which may be suggested by previous experience with such engines.

For many years, it has been considered good practice in modern steam-boiler plants to drive the induced draft fan through a variable speed coupling (either hydraulic or electric). With

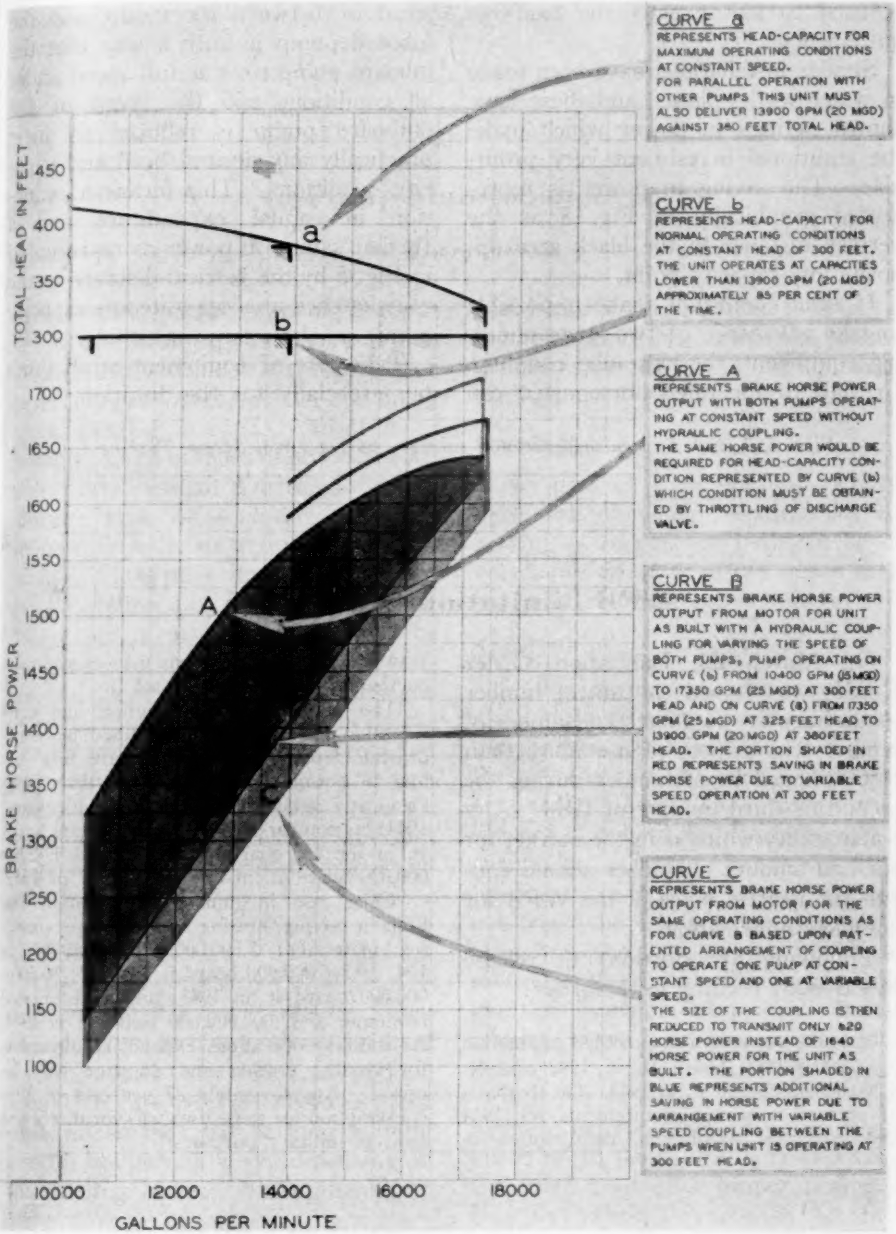

CURVE a
REPRESENTS HEAD-CAPACITY FOR MAXIMUM OPERATING CONDITIONS AT CONSTANT SPEED.
FOR PARALLEL OPERATION WITH OTHER PUMPS THIS UNIT MUST ALSO DELIVER 13900 GPM (20 MGD) AGAINST 380 FEET TOTAL HEAD.
CURVE b
REPRESENTS HEAD-CAPACITY FOR NORMAL OPERATING CONDITIONS AT CONSTANT HEAD OF 300 FEET. THE UNIT OPERATES AT CAPACITIES LOWER THAN 13900 GPM (20 MGD) APPROXIMATELY 85 PER CENT OF THE TIME.
CURVE A
REPRESENTS BRAKE HORSE POWER OUTPUT WITH BOTH PUMPS OPERATING AT CONSTANT SPEED WITHOUT HYDRAULIC COUPLING.
THE SAME HORSE POWER WOULD BE REQUIRED FOR HEAD-CAPACITY CONDITION REPRESENTED BY CURVE (b) WHICH CONDITION MUST BE OBTAINED BY THROTTLING OF DISCHARGE VALVE.
CURVE B
REPRESENTS BRAKE HORSE POWER OUTPUT FROM MOTOR FOR UNIT AS BUILT WITH A HYDRAULIC COUPLING FOR VARYING THE SPEED OF BOTH PUMPS, PUMP OPERATING ON CURVE (b) FROM 10400 GPM (15 MGD) TO 17350 GPM (25 MGD) AT 300 FEET HEAD AND ON CURVE (a) FROM 17350 GPM (25 MGD) AT 325 FEET HEAD TO 13900 GPM (20 MGD) AT 380 FEET HEAD. THE PORTION SHADED IN RED REPRESENTS SAVING IN BRAKE HORSE POWER DUE TO VARIABLE SPEED OPERATION AT 300 FEET HEAD.
CURVE C
REPRESENTS BRAKE HORSE POWER OUTPUT FROM MOTOR FOR THE SAME OPERATING CONDITIONS AS FOR CURVE B BASED UPON PATENTED ARRANGEMENT OF COUPLING TO OPERATE ONE PUMP AT CONSTANT SPEED AND ONE AT VARIABLE SPEED.
THE SIZE OF THE COUPLING IS THEN REDUCED TO TRANSMIT ONLY 620 HORSE POWER INSTEAD OF 1640 HORSE POWER FOR THE UNIT AS BUILT. THE PORTION SHADED IN BLUE REPRESENTS ADDITIONAL SAVING IN HORSE POWER DUE TO ARRANGEMENT WITH VARIABLE SPEED COUPLING BETWEEN THE PUMPS WHEN UNIT IS OPERATING AT 300 FEET HEAD.
TOTAL HEAD IN FEET
BRAKE HORSE POWER
GALLONS PER MINUTE
a
b
A
C
10000
12000
14000
16000
18000

FIG. 5.

this type of drive, the speed may be reduced to suit exactly the load requirements.

Similar installations have been made in water works plants, and these have shown savings in power which make the additional investment very profitable. The saving in power is represented graphically in Fig. 5 as the vertical distance in the black area opposite any capacity point.

If head conditions make it possible to take advantage of two-stage pumping equipment, the hydraulic coupling, for half of the rated horsepower, can be placed between the two pumps instead of between the motor and the inboard pump in such a way that the inboard pump runs at full speed under all conditions and the speed of the outboard pump is reduced to meet practically any desired head and capacity conditions. This means a reduction in capital expenditure and a further saving in power as represented in Fig. 5 by the vertical distance in the gray hatched area opposite any capacity point.

Take care of equipment at all times but especially for the duration.

Figs. 1, 2, 3, 4, 5, furnished through courtesy of De Laval Steam Turbine Co.

WPB Limitation Order L-335

On March 22, Limitation Order L–335, was issued to control lumber requirements. It affects consumers of lumber who expect to use more than 50,000 board ft. of lumber during the second or third quarter of 1944. Any water utility which is in the market for such an amount of lumber should consult the nearest office of the WPB for complete information.

Following are portions of release WPB–5251 relating to the order:

"Lumber consumption exceeded production by 6,900,000,000 board ft. in 1942 and by 4,200,000,000 board ft. in 1943. On the basis of present estimated requirements for 1944 and estimated production, consumption in 1944 under existing controls may exceed production by 4,500,000,000 board ft.

"The gap between production and consumption has thus far been filled by withdrawals from stocks. These are now too low to permit further withdrawals. They stand at 7,284,000,000 board ft. (1st quarter 1944) as compared with 11,229,000,000 board ft. in the 1st quarter of 1943, and 17,299,000,000 board ft. in the 1st quarter of 1942.

"Chief rise in lumber consumption has been in boxing, crating and dunnage (packing material): 5,500,000,000 board ft. in 1941; 9,546,000,000 board ft. in 1942; 16,500,000,000 board ft. in 1943; and an estimated minimum of 17,000,000,000 board ft. in 1944. As military operations expand, requirements for boxing, crating and dunnage will increase. Approximately 87 per cent of 1943 consumption for these uses was for direct and indirect military purposes."

Pump Maintenance

By Harry Stock

THE three major pumping stations of the Minneapolis Water Works Department include eighteen large centrifugal motor-driven pumping units, ranging in capacity from 20 to 50 mgd., and a number of miscellaneous units such as small centrifugal pumps, plunger type of sludge pumps and steam-driven boiler return feed-water pumps. The need for emergency repairs is reduced to a minimum during the season of peak demand, since the pumps are inspected each fall and winter and those units which show signs of giving trouble, if continued in operation for another season, are taken down and repaired. The inspection covers the following parts: packing, bearings, couplings, sleeves, impellers, labyrinth rings, body of pump and alignment and setting of pump.

Packing

The packing of a pump should be soft and pliable and still be tough enough to withstand strain without washing out. The rings of packing should be carefully cut and the gland so adjusted that the packing is tight enough to permit a slight leaking of the cooling water. In tightening a gland care should be taken to bring up the bolts uniformly so that the packing will be subjected to the same pressure throughout.

Bearings

No part of a pump unit requires more attention and repair than the bearings. In general, they can be divided into two types—the sleeve bearing and the ball or roller bearing.

Sleeve Bearings

Sleeve bearings are more commonly used in large units, perhaps because they function satisfactorily as long as they have enough oil, even though they are badly worn. In rebabbitting a bearing it is important to have the oil channeling correct. In a well-fitted bearing there must be a clear oil channel from the point where the oil is brought to the shaft and bearing by the oil ring to the sump. This is especially true of bearings taking end thrust, which, when excessive, will cause heating.

When a bearing wears to a point where it has too much play it is rebabbitted or replaced with a new bearing and fitted to give the proper clearance. One thousandth of an inch per inch of diameter is satisfactory, but it is a good policy to follow the recommendation of the manufacturer.

Plenty of good oil helps to keep the

A paper presented on March 16, 1944, at the Minnesota Section Meeting, St. Paul, Minn., by Harry Stock, Civ. Engr., Minneapolis Water Works Dept., Minneapolis, Minn.

wear at a minimum. The oil should be inspected at the time the pump is gone over and replaced if in bad condition.

Sleeve bearings sometimes become pitted due to stray electric currents which enter the bearing and pass from the babbitt to the shaft. To avoid this the bearing pedestal is insulated, thus preventing the current from grounding.

Ball and Roller Bearings

Ball and roller bearings are conceded to be the most efficient. They are made in a wide range of types, each of which performs a specific duty. The self-aligning bearing is so constructed that any slight misalignment is automatically corrected without causing a strain in the bearing. Two other types are the fixed bearing, which takes a radial load only, and the type designed to take end thrust in addition to radial load.

Where ball or roller bearings are used it is extremely important that the alignment of the entire pumping unit be very accurate. This type of bearing, unless self-aligning, has practically no clearance and any wobble in the shaft causes a strain in the bearing; the result is a broken ball or roller and a badly worn case and shaft. The correct amount of grease is essential to the maintenance of this type of bearing, as too little or too much will cause heating and wear. Ball or roller bearings require but a small amount of oil and care should be taken not to over-lubricate.

Couplings

Couplings may be divided into two types—the semi-rigid or flexible and the semi-universal coupling.

As a rule, the semi-rigid coupling is used in connection with sleeve bearings. This coupling derives its flexibility from rubber-cushioned bolts, but aside from this feature it is rigid. It is well adapted to babbitt bearings because of the liberal clearance allowed in the bearing. It is important that the coupling be machined accurately so that when forced on the shaft the concentricity of coupling and shaft varies not more than .003 to .004 in.

The semi-universal type of coupling is customarily used with roller or ball bearings. As stated before, these bearings have practically no clearance and it is difficult to line up a semi-rigid coupling accurately enough so as not to put too heavy a load on the bearing. By using a coupling which has some universal action this danger is overcome.

In one of the pumps at Minneapolis (a tandem unit equipped with ball bearings) both the inside bearing and the thrust bearing at the end of shaft of booster pump became noisy. The pump was dismantled and both bearings were found to be in bad shape. It developed that when the unit was installed by the manufacturer the split in the casing and all machined surfaces were assumed to be true and the alignment was made from these surfaces. They were just enough out of line, however, to put a heavy lateral load on the ball bearings, and as a result the shaft turned in the bearing instead of the bearing in the race, and the shaft became badly worn at both bearings.

The end of the shaft which entered the end thrust bearing was so worn down that it developed a shoulder on the shaft but, as it was only the last inch or so, it was built up by arc welding and then ground to size. In repairing the inside bearing, however, it was feared that arc welding would warp the shaft, so the shaft was built up by means of metallizing and then turned down on the lathe by grinding. This pump is now operating smoothly.

Sleeves

A bronze sleeve, the ends of which are so machined that they form a watertight seal, slips over the shaft of a pump and serves to confine the water to the impeller and prevents the shaft from contacting the water.

Where packing occurs sleeves eventually become so badly grooved that it is impossible to adjust the packing properly and the sleeve must either be replaced or built up by metallizing and then turned down to size.

Impellers

Impellers, except for small sizes, are made of bronze and are either the "open" or "closed" type. In general, the closed type is used for fresh water. After a certain amount of service, impellers have a tendency to work loose on the shaft, thus causing a leak in the sleeve. New keys will sometimes remedy this situation but very often the impeller must be rebored, in which case the shaft has to be built up, preferably by metallizing, and turned down to fit the new bearing.

Impellers sometimes develop cracks due to vibration or to strains set up in the impeller when it is cast. Small pits can be arc welded quite successfully, but as yet no satisfactory method has been devised to mend a crack. An attempt has been made to preheat and weld the impeller but the melting point of the present-day welding material is so high that to heat the impeller to this temperature usually takes the life out of the metal and sets up such excessive stresses that the impeller cracks again. When an impeller becomes too badly pitted or cracked it should be replaced with a new one.

Labyrinth Rings

Labyrinth rings confine the water to the impeller and raise the efficiency of the pump. They will wear in time and in some cases come loose and batter the threads on the impeller. When this occurs new threads have to be cut and a new ring made to match.

Body of Pump

The body of a pump may sometimes become pitted due to the fact that the material is not absolutely uniform in texture, but these pits are not difficult to repair. The holes can be chipped in such a way that when filled with iron cement, the cement will hold and give a satisfactory surface or the pits can be built up by metallizing and then ground smooth.

Pump Alignment

Pumps may become misaligned due to actual shifting on the foundation and when this occurs, it is necessary to shim up the pump on its base until the pump and motor shaft are again in true alignment. Sometimes both motor and pump, including the motor stator which may have to be raised or lowered, must be reshimmed.

Quite often a motor bearing persists in running hot, despite the fact that the bearing is perfect. In such cases it has been discovered that in finding its magnetic center, the rotor of the motor shifts, and unless the motor is set to allow for this shift, the collar on the shaft rubs the bearing and causes it to heat. This condition is remedied by moving the motor slightly on its base. This requires new alignment dowels and the old holes should be reamed out and new dowels installed.

One of the high service pumps at Minneapolis is supplied on the suction side from the Columbia Heights Filtration Plant by a gravity head of about 185 ft. and acts as a booster pump to raise the head in the system to about 250 ft. Whenever the suction head

came onto this pump the pump actually moved upward and to the south. Each winter the pump had to be moved north and realigned. The trouble was traced to the faulty foundation on which the manufacturer set the pump and also the inadequate base plate used. In addition, the piping to the pump was of such character that any movement in the piping due to pressure or temperature change reached the pump and actually moved it. The pump was removed and substantial foundation and heavy concrete base plate constructed. The expansion joints in the pipelines were shifted so as to prevent all pipe movement from being transferred to the unit. This incident illustrates the importance of setting and aligning a unit accurately.

The repair of small centrifugal units is similar to those of the large units but the plunger type of sludge pump requires special attention. When a plunger wears to the point where it needs repairs, it is turned down and then by metallizing built up with a harder material (high chrome stainless steel) and then ground down to size. This is working satisfactorily at Minneapolis and it is hoped that the life of the plunger will be prolonged by this treatment.

In maintaining a number of pumping units it is advisable to adopt a definite scheme of inspection which will enable the maintenance crew to detect troubles before they become serious and thus avoid major repairs.

Reprints of "National Inventory of Needs for Sanitation Facilities Public Water Supply," by H. W. Streeter and Ray Raneri, which appeared in the March Journal, are available from the Superintendent of Documents, Washington, D.C. The reprint is No. 2535 and the cost ten cents a copy. Personal checks are not accepted. Send coupons, which can be purchased from the Superintendent of Documents, or a money order with your request for reprints.

The American Water Works Association will not have reprints of this article for sale, since this would be a duplication of the reprint now available from the Superintendent of Documents in Washington.

Maintenance and Repair of Meters

By George A. Roden

METERS are brought into the St. Paul shop for one of three reasons: a meter reader's complaint, a complaint from a consumer or for a periodic test. Periodic tests have been discontinued for the duration, however, because, from data accumulated over a period of some ten years, it was found that of the large meters (3 in. and over) only 2 per cent have been disconnected because they were defective. The remaining 98 per cent were disconnected because of freezing, burning, discontinued service, plumbing change or similar external effects. Compared with the smaller meters, 50 per cent of which are disconnected because of defects, this speaks well for removing, testing and repairing meters periodically, and the practice will be resumed after the war.

Testing and Repairing Small Meters

A meter is read and noted by the meter setter, after which it is brought to the shop, where it is read again and the reading noted. The shop reading and field reading are made independently, and if there is a discrepancy the error is checked. If the meter is brought in because of a meter reader's complaint, a third reading is made. All readings are noted on a "disconnect sheet" and sent to the Accounting Division. This disconnect sheet also contains the address of premises concerned, the number and make of meter removed, and the same information relative to replacing meter. After testing the meter, any information pertaining to a decrease in consumption or similar circumstance is also noted on the disconnect sheet. Any meter found to be stopped is dismantled and inspected. All tests are recorded on a "daily examination sheet" and filed for future reference.

So far the services of only one shop man have been required. The meter being tested is now passed on to another shop man who dismantles and renovates it. Cleaning is accomplished by an acid bath, immersion in hot water and drying by compressed air, in the order given.

The dismantled meter is then taken over by repairmen. The most important feature in the repair of a meter is the fitting of the disc to the measuring chamber. Most discs are purchased with over-sized half balls, and when a disc has standard-sized half balls, brass shims of proper thickness are placed between the disc plate and half balls. The fitting is accomplished by placing the disc in a chamber, which is kept shut by clamps, and increasing the pressure as the disc is ground. Grind-

A paper presented on March 16, 1944, at the Minnesota Section Meeting, St. Paul, Minn., by George A. Roden, Water Dept., St. Paul, Minn.

ing is accomplished through the medium of a fine-textured compound mixed with water. The proper amount of grinding is apparent to the experienced repairmen by touch and observation. Intermediate gears are inspected and, if worn, are replaced with new ones. (Repairing of intermediate gears and registers is the function of another repairman and will be described later.) Spindles are repacked and a new or repaired register is placed in the meter. All worn bolts, gaskets and broken bottoms are replaced. The meter is tested for accuracy on a minimum and maximum flow. Meters must register accurately within the prescribed limits, both on minimum and maximum flows, without recourse to change gears differing from the standard by more than two teeth. The practice of repairing meters through the medium of change gears is to be condemned, for although the lag in a meter may be corrected by change gears, as the disc wears the lag may correct itself and the result is a fast meter.

Costs Combined

After the meter has been repaired and tested, the repairman notes on the reverse of the disconnect card the material used, the time involved and the change gears used. The disconnect card has been previously used as a work card for the meter setter. No attempt is made to keep costs on individual meters, but all figures pertaining to make, type and year purchased are combined, thus giving maintenance costs for makes and types of meters over a long period of years.

In the St. Paul shop the repair of intermediate gears is done by one man, thus avoiding duplication of jigs and fixtures, and one punch press is sufficient. The work consists of straightening bent frames, replacing worn-out control rollers, worn spindles and worn gears, and inserting rubber bearings where the original bearing was metal-to-metal. It has been demonstrated that such work results in a saving of 50 per cent on the purchase of new intermediate trains.

After testing disconnected meters, all registers are removed, and where there is a decided discrepancy between the shop reading and that of the meter reader, those registers are placed on file until the error is ironed out. Register repair receives the attention of one individual and consists of replacing worn spindles and illegible dials and resoldering and repainting hands. All registers are set back to zero reading.

Testing and Repairing Large Meters

Large meters are repaired in the same fashion as outlined for the smaller meters, and this work is assigned to one individual especially trained for that purpose. The testing of large meters is complicated as the test consists of a range of flows. Especially is this true in the testing of compound meters where the action of compounding valve must be observed to determine the efficiency of the meter during the "change-over" period.

Practical experience, which can only be acquired by actual handling of meters, rather than skill as a machinist, is required in the repair of meters. There is no intricate machinery in the St. Paul shop—only one motorized drill press, one foot power punch press, two individual testers, two battery testers and one tester of our own construction for the larger meters. The large tester and one of the battery testers are equipped with a mercury column, making it possible to determine

the capacity curve for any size meter. The individual testers are equipped with multiple orifice valves and the battery testers with "Testerates," which indicate the rate of a flow in quantity per minute. The orifice valves serve the purpose but should be calibrated from time to time. Furthermore, a rate indicated as a ⅛- or ½-in. orifice is meaningless when it is considered that the flow may vary with the variations in pressure.

As previously mentioned, 3-in. and larger meters were being removed and repaired under a routine of periodic tests. As soon as circumstances permit, this routine will be resumed and extended to the removal of smaller meters. The periodic tests were based on the following intervals of time:

Size—in.	Yr.
⅝, ⅝ × ¾	20
¾, 1	15
1½ to 2	12
3	5
4	4
6	3

The maintenance of meters necessitates the use of various forms, some only incidental but others quite pertinent to the meter division. The necessity for such forms will vary with different shops according to the demands for records and cost data and the desires of the supervisors.

Another phase of meter maintenance which, although it does not include repairing meters, is very pertinent to the subject, is the question of "high bill" where the meter is very often made the goat. This problem has been solved by the use of the "Meter Master Rate Recorder" which is connected to an approved meter and charts a continuous rate of flow for 24 hr. If, during the night when normally there should be no flow, a steady flow is indicated, we know that there is a leak in the fixtures. This instrument also records the peak loads.

The cost of repairs per meter in the St. Paul shop for the year 1943 was as follows:

Administration	$ .79
Labor	
Testing	.10
Dismantling and Cleaning	.15
Repairing	1.25
Painting	.06
Material	
Cleaning	.02
Meter	.96
Paint	.02
Transportation	.03
Tools and Equipment	.04
Total	$3.42

Although this total may seem high in comparison with other published cost data, it should be kept in mind that this schedule includes even the cost of water for testing, which, although the production department is not reimbursed, reduces the element of "unaccounted for water."

Another instrument frequently used is the recording pressure gage. This instrument makes it possible to determine the loss of head through the service connection at different rates of flow and thereby to determine the efficiency of the connection.

Every community should have some means of testing meters. While a portable tester may serve the purpose, it does not compare favorably with a shop test. Many states require a test at periodic intervals and define the accuracy required at different rates. Many of the tools required for disassembling meters can be purchased from the meter manufacturers. A small spray booth where meters are sprayed with an aluminum paint before being put in service is part of the equipment of the St. Paul shop.

Hydrant and Valve Inspection and Maintenance

By Carl W. Seemann

ACCORDING to local history the Minneapolis water plant was authorized in 1867. Some of the early-day pipes were made of sheet iron and cement and remains have been found of bored-out lumber, coated with tar or pitch. In some larger sizes water pipe was made up of longitudinal sections of wood, bound with metal circular bands.

The records of existing structures do not mention the existence of wooden or other built-up pipe. The oldest pipe now in use is made of cast iron and was laid in 1871–72, about 72 yr. ago, and is still in good condition. Apparently these early cast-iron mains had replaced the sheet-metal and wooden mains.

The system now consists of 863 mi. of water mains, 826 mi. of which are cast-iron pipe and 37 mi. steel distribution mains. These mains vary in size from 6 to 84 in. in diameter.

There are about 10,500 gate valves in the system, varying in sizes from 6 to 66 in. in diameter. The active services number about 99,000. There are a large number of "to curb only" services laid under paved streets for future use on vacant property and suspended services where buildings have been wrecked. The records also show the existence of 7,330 hydrants in the system. In the downtown areas two hydrants on diagonally opposite corners make up a common installation, and in high value districts a hydrant is placed in a mid-block location to shorten hose lay-outs for fire use. It is the duty of the water service group to maintain and operate the equipment in the distribution gridiron and attend to all matters related to this part of the water system.

Hydrant Repairs

When extensions are completed the service department takes over; water is turned on and the new line is tested, chlorinated and flushed after thorough sterilization by the purification group. Measurements are made for the tie-in of all gates to hydrants and other permanent points or objects. Records are made up for shut-off purposes under service conditions and in emergency cases when mains break.

Non-jacketed hydrants have been used in recent years, but many older types require jackets or brick chambers. When hydrants are broken by traffic the standpipe can, in some cases, be drawn up through the jacket; otherwise the earth around it must be excavated and the hydrant lifted out. Each year about 70 to 80 hydrants are broken by traffic.

A paper presented on March 16, 1944, at the Minnesota Section Meeting, St. Paul, Minn., by Carl W. Seemann, Gen. Foreman, Water Service Dept., Minneapolis, Minn.

It is frequently difficult to collect for damage to hydrants by traffic. Usually such damage is the result of a collision or a maneuver to avoid collision and the "other fellow" is blamed. After arguments and legal efforts the burden of cost falls upon the water department, which is in no way responsible for the damage.

Broken hydrants are usually repaired by the service men. Unless the barrel is shattered it can be "set" with a longitudinal rod, heated, welded together and re-used. The shop is equipped with spare materials and parts, so that but a minimum number of damaged hydrants are totally lost and the average life of a hydrant is thereby prolonged by these facilities.

In severe winter weather all downtown hydrants are checked and tested daily for leakage and freezing. In the outlying areas less frequent inspections are made, but the total individual inspections vary from 50,000 to 80,000 each season, according to weather conditions.

Numerous minor hydrant repairs are made in the field, together with testing and oiling. About 10 per cent are allocated for painting each season, the favorite color being red although it is not as enduring as green. In downtown areas hydrants are painted red and in residential areas green posts and red caps are used.

The servicing of mains is usually confined to flushing and to repairing leaks, a considerable percentage of which are in the services.

In the early days hydrants were located at street corners in line with intersecting street frontage. Adjustments were made to accommodate catch basins, but the hydrants as set were found to be within the dangerous area of automobile or truck collisions. It is the opinion of the maintenance force that hydrants should be located about 40 ft. back from intersecting street lines. The spacing distances would be exactly the same as before, but the hydrant would no longer be a "bull's eye" for reckless drivers.

Of the 7,330 hydrants in the city, 2,664 are equipped with a valve on the branch and 381 of these valves have manholes instead of boxes. It is essential that valves be in operative condition at all times. Their location or position should be explicitly recorded and the record should show which way the spindle turns to open and the number of turns required. After use they should be inspected and their position relative to "open" or "shut" noted.

The opening and closing peculiarities of valves must be known and noted. Care should be exercised when the force is applied, especially where large mains are involved. The operation of large valves in an extensive system should be carefully studied and, in an emergency the key men, after starting the shut-off, should make a survey of the situation so that the final closure may be safely accomplished, shutting the large valves first and the small ones last.

When the flood of a main break is at its height, with damage on every side and a water famine in remote parts of the city, the superintendent and his men need ample fortitude to see the closure completed. It is essential therefore that all of the appurtenances of the system are kept in working order to meet all emergencies. The service man is not blamed for breaks but he may be blamed for the manner in which the shut-off is handled.

The department has a repair truck equipped with independent power and

light generators, a valve operating device as well as many other tools and bench equipment, a veritable "shop on wheels" for repairs and service work in the field.* This truck follows all breaks and important shut-offs.

The service department also has charge of water service connections; makes all taps at the main using $\frac{5}{8}$-in., $\frac{3}{4}$-in. and 1-in. service cocks, and in the larger sizes uses sleeve and valve connections. All taps have tie-in location records which are filed for use in relocating the taps and stops in cases of leakage, discontinuance or other proper purposes.

It has been the practice to install services for vacant property from main to curb where streets are paved, the wisdom of which appears to be debatable but no recommendations have appeared.

The service division is housed at the water works shop and storage yard. Men work day shifts, skeleton crews are employed at night, and all outside men are subject to call. The crews are made up of clerks, a storekeeper, a blacksmith and helper, repair men and regular service men. The chief service foreman has assistants and schedules are made for handling the work. There is a blacksmith shop; there are hydrant and valve repair facilities; also, automobile servicing, turning off and on of water, notification, inspection and general disposition of complaints and customer calls.

* New Emergency Truck Equipment for Minneapolis. Jour. A.W.W.A., **30**: 1974 (1938).

Co-operative Meter Reading

THE public utilities of Wellsville, N. Y., have united in a consumer relations program, which has the added purpose of saving manpower during the war. E. J. Rowe, Superintendent of the village water and light department, originated the idea.

Mr. Rowe reasoned that, since practically all homes and commercial premises in Wellsville took gas service from a privately-owned company * and water and electric service from the municipally-owned plants,† it was practical to consider reading all utility meters at the same time, thus reducing the number of visits to consumers' premises for this purpose.

At the suggestion of Mr. Rowe, a conference was held, which was made up of officials of the local gas, electric and water utilities. Members of the conference believed that consumers would welcome having their meters read at one operation.

A plan was agreed upon by the utility group, whereby a meter reader employed by the gas company would read all gas, electric and water meters within his regular territory, and a meter reader from the water and light plant would read gas meters along with his regular readings. Each meter reader was to report all utility readings to the main office from which he worked, the readings to be collected by an employee from the individual utility.

Three men are now reading meters which formerly were read by four men.

It would be interesting to know whether such an experiment has been tried elsewhere, and with what success.

* Municipal Board of Water and Light Commissioners, Wellsville, N. Y.

† Empire Gas and Fuel Co., Wellsville, N. Y.

Report of a Research Project* on the Effects of Electric Grounding on Water Pipes

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THE grounding of electrical circuits has been universally accepted as a safety measure wherever an electrical potential of any appreciable magnitude is encountered. Grounding is necessary, not only for the protection of the individual using the electrical fixture or appliance, but also for the electrical circuits and machinery involved. Unless all objects capable of conducting electricity and within the normal reach of a person are at the same potential, a difference in potential might result in the passage of current through the body of that person. The danger from the resulting shock would depend on the difference in potential and the current flowing through the body.

Although it is granted that grounding is essential, the specific methods of accomplishment have long been the subject of controversy. The easiest method has been to ground all electrical appliances to the nearest water line. This permits the current to be conducted through the water pipes of the building into the underground water distribution system, thence to be dissipated into the ground itself or transmitted back to the power station.

That the American Water Works Association has long been cognizant of the potential dangers is reflected in the statement of policy (1) of its Board of Directors dated March 1, 1944:

> "This Association notes, on behalf of water works executives generally, that the grounding of electric services upon water pipes is understood to be desirable in the interest of safety of the users of electric current. It observes that water departments and companies do not install such connections; derive no benefits from them; may be damaged by them; and tolerate them only because of their reputed importance in providing electric service safely."

Separate grounds have been installed in many special cases, particularly where there is a large difference in potential. Many engineers have advocated separate grounds for all electrical circuits, eliminating all possible connections to the water systems. Reasons for this have been varied, but the most prevalent one has been the claim that internal corrosion of the water lines will result, with consequent effect on the quality of the water, as evidenced by tastes and odors (2).

It is important to distinguish between internal and external corrosion

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of pipelines. Corrosion of the external surfaces of pipes has been the subject of extensive research (3) by the utilities whose large investments in underground water, electric, telephone, gas and oil lines have been subjected to heavy losses. Theories have been well formulated and proved by long practice so that remedial action is available (4) for the control of external corrosion where pipelines lie buried in soils of various types.

Internal corrosion of pipelines has also been subjected to wide research by utilities and pipe manufacturers (5), as well as independent research organizations. Problems are somewhat unlike those encountered with external corrosion where a difference in potential between the pipe and the ground will cause metal to be lost from the pipe. Internal corrosion takes place with no over-all differential in potential between the pipe and the liquid contained therein. Where a pipe is carrying a current, as in the case of grounding, both pipe and liquid may be considered as branches of a parallel circuit, with all but an infinitesimal amount of the current flowing along the metal and no difference in potential between pipe and water at the interface. When corrosion takes place, electrolytic cells form between adjacent points on the internal surface of the pipe. A minute current will flow from one point on the pipe through the liquid to the adjacent point, carrying with it a metallic ion which goes into solution, replacing a hydrogen ion in the liquid. The increase of metallic ions in the liquid is an index of corrosion. Not all of the ions remain in solution, as many react with oxygen and are precipitated out as metallic oxide, which in the case of iron pipe is rust. Theories of internal corrosion have been well formulated through years of painstaking research. Although great strides have been made, much remains to be done before elimination of the difficulties resulting from tuberculation, destruction of pipes, red water, blue stains and other matters relating to the presence of metallic ions in water reaching the consumer.

Observations by water works operators and others have shown that the visible effects of internal corrosion may sometimes be aggravated by the use of a water line within a house as an electrical ground. It has been the practice of some water purveyors to trace causes for complaints resulting from blue stains on fixtures fed by copper pipes, and cases of red water where steel pipe is involved. In some cases, where stray currents were removed from the water pipes, it was claimed that less deleterious effects were noted. In other cases, the removal of grounding connections did not have any appreciable effect. Controversies have developed among the various interested parties, particularly the water and electric utilities, concerning the effects of grounding on the internal corrosion of water lines. Answers to these questions can only be achieved by extensive research, taking into account all of the variables involved.

In an effort to accomplish the much-needed research and to bring all interested agencies together in an impartial manner, the American Research Committee on Grounding appointed a Technical Subcommittee in 1936. To this committee was assigned the task of investigating corrosion of pipes alleged to be caused or aggravated by stray currents, originating through grounding of electrical circuits.

Over one hundred cases of unsatisfactory water conditions have been referred to the Technical Subcommittee.

Investigations have been made of stray currents, the metallic content of water reaching the consumer and conditions of the pipes in the households involved. In most cases, adjoining houses have also been investigated to observe whether similar conditions prevailed in the neighborhood. In a few instances the Technical Subcommittee (6, 7, 8) has been able to eliminate stray currents on certain pipes which had previously experienced difficulties. Analyses are being continued to observe the effect of the removal of grounding currents.

In 1933 a research project was initiated under the direction of M. Warren Cowles at the laboratories of the Hackensack Water Co. The objective of this research was to isolate all of the variables involved and to control them in such a manner that observations could be made on the effects of a few selected variables. In essence, the work involved the installation of triplicate series of galvanized-iron, copper, brass and lead pipes. One pipe of each set carried alternating current, one direct current and one was insulated to carry no current.

Water was passed through each of the pipes and analyses were made for changes in the constituents during flow through the pipes. The analyses included metallic ion concentrations, tastes, odors, conductivity, dissolved oxygen, temperature and other data considered pertinent. Results (9) were not conclusive, but the path was opened for additional research at such a time as the subcommittee deemed advisable.

This plan was held in abeyance for such an extended period that in 1940 the Water Works Practice Committee of the A.W.W.A. decided to initiate a research program on the effects of electrical grounding on water quality. Funds were allotted to establish a research fellowship at the College of Engineering of New York University so that an assistant could be assigned to the grounding research. Plans for the program (10) were discussed and formulated with the assistance of the members of the Technical Subcommittee so that all interested agencies would agree as to the validity of the tests and the bases upon which they were founded.

The object of this research was to determine the effect of electric grounding on the quality of the water flowing through the pipe to which the ground was attached. This could best be achieved by analyzing the variables involved and determining which could be maintained constant in order to observe the effect of two principal variables—the type of current and the type of pipe.

Characteristics of Water

Characteristics of the water passing through the pipe were among the most important variables to be brought under control. For the purpose of the tests it was desirable that the water should be corrosive in nature but as constant as possible in mineral analysis. To fill these requirements, New York City water from the Catskill supply was chosen for the tests.

This water is impounded for long periods in large reservoirs so that mineral analyses are quite uniform over the course of a year. The water receives no treatment other than aeration, and long period sedimentation, and chlorination. The Catskill and Croton Aqueducts convey the water over one hundred miles to the city. Most of these aqueducts are reinforced concrete with short stretches of steel pipe. Distribution mains in the city are steel and

cast iron. The laboratory in which the tests were conducted is located only 1,500 ft. from the main aqueduct so that a uniform supply was assured.

The service main for the laboratory is a 2-in. galvanized wrought-iron pipe connected to a 1-in. tap in the street main. At the building line a transition is made to yellow brass. All water piping from the house main to the experimental set-up is also yellow brass.

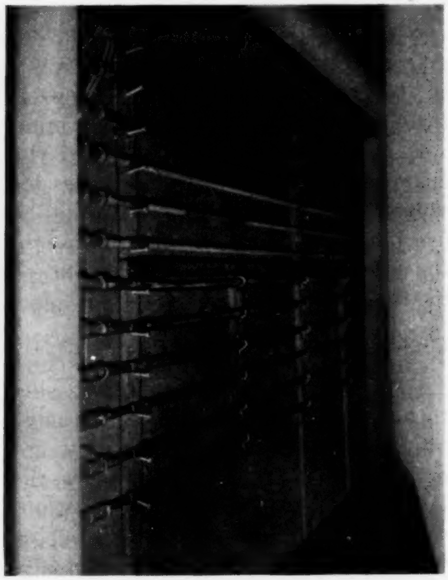

Fig. 1. Pipe Setup-Influent End

A 1-in. yellow brass branch leads to the asbestos cement header of the set-up.

A check of pressures both in the building and at the curb hydrant indicated pressures ranging from 70 to 90 psi. This range is probably due to variations in flow in the supply network of the locality.

Analyses of the Catskill water, made over a period of many years by the Mount Prospect Laboratory of the New York City Department of Water Supply, Gas and Electricity (11), indicate that the following characteristics prevail:

	ppm.		*ppm.*
Total Solids	40	Alkalinity (as $CaCO_3$)	11
Fixed Residue	29	Carbonate	0
Calcium	5.8	Bicarbonate	14.0
Magnesium	1.4	Sulfate	9.7
Sodium	1.7	Chloride	2.0
Potassium	0.7	Nitrate	0.5
Other Metals	Traces	pH	6.95
Hardness (as $CaCO_3$)	19		

Pipe Materials

Pipes of four different materials were used in this grounding research. These materials were red brass, copper, galvanized iron and lead. All pipes were purchased on the open market so that they would represent materials normally in use in domestic service. Three 21-ft. lengths of Wolverine Grade A, 85–15, red brass pipe were purchased from the same stock. Three 21-ft. lengths of Mercer Tube Co. galvanized-iron pipe were also purchased from the same stock. As far as could be ascertained, each group of pipes came from the same mill shipments. The copper pipe was Wolverine, Type K, and was purchased in a single coil 60 ft. long and then cut into three lengths. The same procedure was followed with the lead pipe manufactured by the Flemm Lead Co. Thus, each group of pipes was as similar in composition as could be obtained on open stock purchase.

The arrangement of the pipes for the experimental set-up is shown in Fig. 1. Pipes of the respective types were grouped together and installed against a vertical wall. The three red brass pipes were at the top, followed below by the three galvanized-iron pipes, then the lead, and finally the three copper pipes nearest the bottom. Spacing of the pipes was chosen as 6 in. on cen-

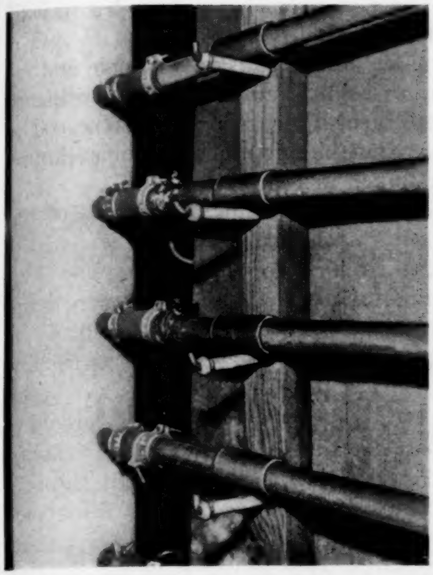

FIG. 2. Detail at Influent End

ters in order to eliminate any interference from induced electric currents from adjacent pipes. All of the pipes were sloped upward to permit released oxygen to flow out with the effluent.

Pipe Supports

Mounting of the pipes was accomplished by anchoring wooden 2 x 4-in. studding to the concrete wall and supporting the pipes by metal clamps attached to the studding. To insure insulation, each pipe was enclosed in a heavy piece of rubber tubing, 3 in. long, immediately over each support (Fig. 2). A special arrangement to provide for flexibility was made at the influent end where the pipes were supported over bolts covered with porcelain insulators, as shown in Fig. 3. Resistance measurements indicated values in the order of 300,000 ohms between adjacent pipes, thus attesting to the effectiveness of the insulation and insuring against stray currents.

Rate of flow was controlled through the pipes by means of non-metallic valves arranged so that no stray currents would be encountered. A glass capillary tube of proper bore was inserted through a rubber stopper. On the galvanized-iron and red brass pipes a stopper was forced into the end of each pipe and held secure by a hard rubber cap screwed onto the pipe, as shown in the upper portion of Fig. 3. On the lead and copper pipes it was necessary to connect each pipe with a stopper by means of rubber tubing and clamps. A short length of rubber tubing followed each capillary, with a laboratory type screw clamp to control the flow. The tubing arrangement following the pinch clamp, as noted in Fig. 3, merely served to carry away the effluent.

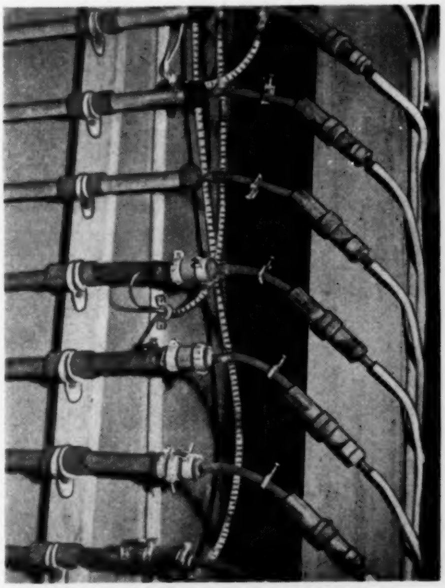

FIG. 3. Detail at Effluent End

Electrical Circuits

Three separate pipes of each of the four materials were provided, making a total of twelve pipes mounted on the wall as previously noted. Three different current conditions were desired for each type of pipe. Alternating current was connected to the first pipe in each group, direct current to the second and no current to the last.

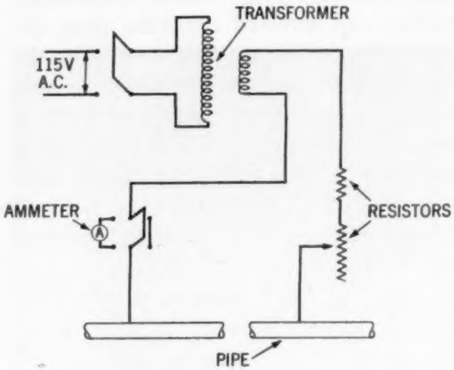

FIG. 4. Alternating Current Circuit for One Pipe

Separate circuits were provided for each pipe in order to prevent any flow of current from one pipe to another. Based on past experience with grounding currents, it was the opinion of the Technical Subcommittee that a current of 1.25 amp. would approximate field conditions. This current was applied to all pipes carrying alternating or direct current.

Resistance of the metallic pipes to the flow of current was extremely low. In order to provide a circuit with a steady flow of current it was necessary to install resistors in series with each pipe. Two resistors were provided, one fixed and the other variable. Current in each circuit could be adjusted to and maintained accurately at 1.25 amp. by means of the variable resistor. These resistors were employed in both the a-c. and d-c. circuits.

The a-c. circuits were simple and required only transformers and resistors to furnish the proper current. The separate circuit employed for each pipe is noted in Fig. 4.

Since alternating current was the only current available at the laboratory, the circuit necessary to provide 1.25 amp. of direct current was more complex. A transformer stepped down the voltage from 115 v. on the primary to 6.3 v. on the secondary. A copper oxide double-wave rectifier provided a reasonable degree of rectification. This was further smoothed out through the use of a storage battery in parallel with the rectifier. Fixed and variable resistors were provided in the rectifier circuit to give a current of approximately 1.30 amp. The battery circuit also included a fixed and a variable resistor to provide a current of 1.25 amp. to the pipe. The slight excess of current in the rectifier circuit assured a completely charged battery, at the same time furnishing a steady current.

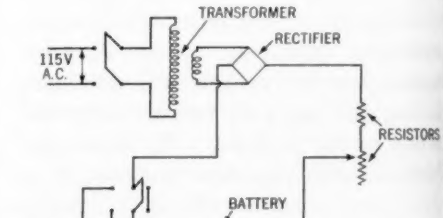

FIG. 5. Direct Current Circuit for One Pipe

This circuit is shown diagrammatically in Fig. 5.

Electrical control apparatus was mounted on a control board, the front of which is shown in Fig. 6. The many toggle switches were necessary

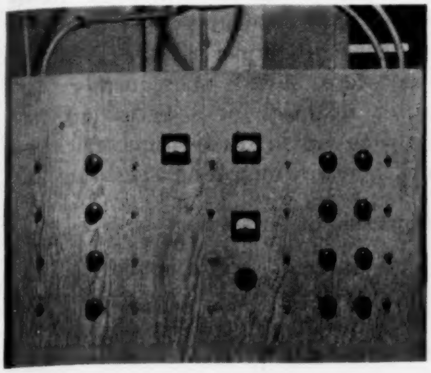

Fig. 6. Electrical Control Board

to connect the various circuits to the ammeters and also to disconnect circuits when necessary. A selector switch provided connections for the d-c. circuits to the voltmeter in order to assure a proper voltage across the batteries. The variable resistors were controlled by the knobs shown mounted on the board.

A rear view of the control board is shown in Fig. 7. The resistors and transformers for the a-c. circuits are located at the right of the figure. To the left of the center are located the resistors, transformers and rectifiers for the d-c. circuits. The storage batteries for each of the four d-c. circuits are evident under the control apparatus.

Four armored cables were provided to carry the current between the control board and junction boxes above the pipes. The direct current to the influent end of the four d-c. pipes was carried in one four-wire cable while that from the effluent end was carried in a similar cable. The same arrangement was provided by two four-wire cables for the alternating current. Two-wire cables carried the currents from the junction boxes to the pipes (Fig. 3). Electrical connections to the individual pipes were provided by means of telephone ground clamps (Fig. 3).

Procedure

Before assembly, the interiors of all pipes were thoroughly cleaned of foreign matter such as grease and then given a final wash with acetone to yield a clean dry surface. After the pipes had been assembled in the manner previously described, they were tested for leaks and made watertight.

Once the water was turned on, the pipes were never permitted to dry during the course of the experiments. In view of the small quantity of water flowing through the pipes, it was necessary to waste water continuously from the asbestos-cement header. This assured a steady supply of fresh water to the pipes.

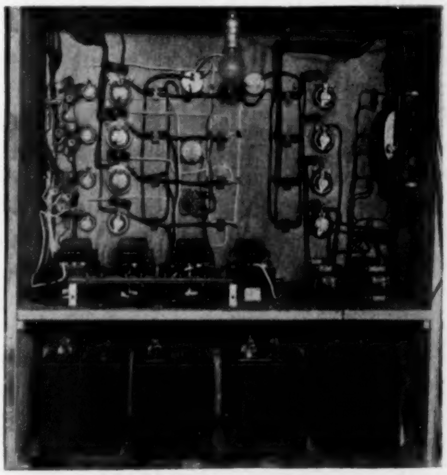

Fig. 7. Electrical Control Board (Rear)

For three months water flowed through each of the pipes at a uniform velocity. No current was applied. This was done in order to age the pipes so they would simulate conditions in ordinary domestic installations and to permit the rate of corrosion to become approximately the same in all pipes of the same material. Current was then turned on and the circuits tested. After a few changes the current was again turned on and remained on during the entire course of the experiments. As stated previously, 1.25 amp. of direct current were applied to four different pipes, 1.25 amp. of alternating current to four others, and no current applied to the four which served as standards.

Test runs were made by shutting off the effluent valves and retaining the water in the pipes for a specified period of time. This permitted corrosion to take place and metallic ions to enter the water from the pipes. Samples of the influent to the pipes were taken from the header just before shutting off the flow. After the desired detention time had elapsed, one liter of water was drawn from each of the pipes. After thorough mixing of each sample, 300 ml. was taken for analysis of metallic constituents. The difference in concentration of metals in the water before and after the detention period had elapsed was taken as the index of corrosion occurring in the pipes under the influence of superimposed currents. Detention periods varied from 6 hr. to 32 days.

Between each run on any pipe the water was permitted to waste for 24 hr. This washed out any loose floc particles which might reflect past instead of present conditions resulting from the test run under consideration.

As the samples of pipe effluents were collected, they were acidified with 0.1 ml. of concentrated hydrochloric acid. This was done to dissolve all the metallic corrosion products and to prevent adsorption of metallic ions on the surface of the glass bottles. All sample bottles were treated with acid for a minimum of 60 days in order to remove any impurities that might be present on the inner surfaces. All bottles were tested subsequently with water retained for a period of time showing no increase in metallic ions, and therefore indicating a clean surface.

Methods of Analysis

In order to approximate the precision required for this type of grounding research, methods of chemical analysis had to be selected to give a high degree of accuracy at extremely low concentrations of metallic ions. Considerable research was devoted to the development and selection of precise methods of analysis for zinc, copper, iron and lead.

Zinc is one of the most difficult metals to measure accurately in low concentrations. Many of the published methods were attempted but proved unsatisfactory. These included turbidimetric, colorimetric and gravimetric methods and all were influenced by interfering substances which could not be controlled.

The polarographic method of analysis (12) was used in the determination of zinc. This method had been developed to a considerable extent during the past decade by physical chemists. It had not been applied to the measurement of such low concentrations of metals as were encountered in these experiments. By applying a combination of techniques a procedure was developed which apparently is the only practical method available for the

determination of zinc in the low concentrations present in drinking water.

Basic principles of polarography and description of the apparatus involved were included in a previous paper (10). Essentially, the apparatus and electrical circuit shown in Fig. 8 are involved. The dropping mercury elec-

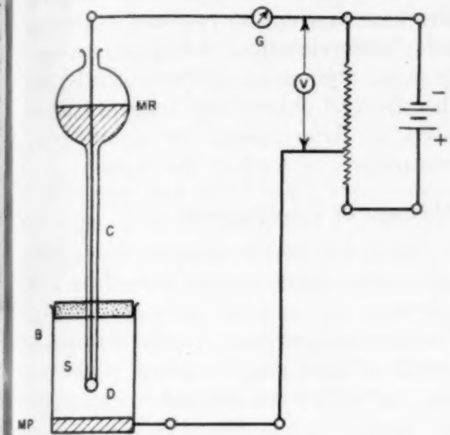

Fig. 8. Dropping Mercury Electrode and Polarograph Circuit

trode consists of a capillary tube, connected to a mercury reservoir at the top and set in a glass cell containing the test solution. At the bottom of the cell is a pool of mercury electrically connected to the external circuit by a platinum wire sealed into the bottom of the cell. For ordinary measurements of metallic ions, the drop electrode is cathodic and the mercury pool anodic. The external electrical circuit is designed to permit regulation of the potential across the electrodes. The current passing from the mercury pool through the solution to the mercury drop is measured by a galvanometer.

Operation of the polarograph involves varying the potential across the electrodes, reading the corresponding currents and plotting a current-voltage curve. As the voltage is increased the flow of current increases gradually with a straight-line variation, until the reduction potential of a particular ion is reached. Within the range of 0.2 v. the current-voltage curve will rise abruptly and then flatten out to assume the straight-line variation at a higher current. The voltage representing the mid-point of the current rise, known as the half-wave or reduction potential, is different for each metallic ion and serves to identify the ion being analyzed. The potentials follow closely the familiar electrochemical series. The height of the current step is proportional to the concentration of the ion. After calibration of the instrument, the increment of current gives the concentration of the ion identified by its reduction potential.

Certain chemicals must be added to the unknown solution to assist in the determination. These include an indifferent electrolyte, necessary to increase the conductivity of the solution, and a suppressor to cut down abrupt rises in the current voltage curve caused by adsorption or catalysis phenomena. Numerous experiments were conducted to determine the proper electrolyte and suppressor to be added to the solution for the analysis of zinc ions. These experiments will be reported in another paper. It is sufficient to state that the most consistent results were obtained using ammonium chloride, with an excess of ammonia, as

the indifferent electrolytes, and gelatin as the organic suppressor. These worked well together and led to an accurate and rapid method for the determination of low concentrations of zinc.

The analysis for copper was of extreme importance in this research inasmuch as grounding experiments were being conducted on copper and red brass pipes. The procedure outlined in "Standard Methods" (13) could not be utilized because consistent results could not be obtained with test solutions of known concentration. Interfering substances such as zinc, iron and manganese had considerable effect on the apparent results. Mr. B. G. Nesin, Chemist-in-Charge of the Mount Prospect Laboratory, under the general supervision of Dr. Frank Hale, had developed a practical method (14) for the determination of copper in extremely low concentrations. This method employed sodium ammonium citrate and sodium diethyldithiocarbamate reagents, with carbon tetrachloride used to extract the copper compound from the aqueous solution. Colorimetric standards may be prepared to read copper concentrations as low as 0.01 ppm. Using this technic, results are easily reproducible and check accurately against known concentrations of copper.

Iron determinations were made using a modification (14) of the method outlined in "Standard Methods." It was found that greater rapidity and color definition could be achieved through the use of 100-ml. low-form Nessler tubes than with the normal 50-ml. type. Permanent standards were prepared using potassium chloroplatinate, hydrochloric acid, distilled water and cobaltous chloride. Consistent results were obtained by this method.

The procedure for the determination of lead was modified (14) from that advocated by "Standard Methods" by using small volumes of samples, not exceeding 20 ml. Extensive heating and evaporation were avoided, thus eliminating the interference of substances effected by dithizone. Changes were also made in the concentration of dithizone reagent to produce optimum color differentiation. Ammonium hydroxide, ammonium citrate-cyanide, dithizone and chloroform reagents were used in determining the small concentrations of lead in the water.

Method of Comparison

After the initial aging period, runs were made following the procedure and methods of analysis previously noted. Tabular and graphical methods of presentation have been resorted to in order to secure the desired comparison of results of the effect of alternating and direct currents superimposed on the pipes.

Table 1 presents the results obtained with the three red brass pipes. Analyses were made for the zinc and copper picked up by the water during the process of corrosion. These analyses have been plotted on linear scales against detention time on a logarithmic scale in Fig. 9. The different current characteristics, namely, alternating, direct and no current, are indicated on the graphs.

It will be noted that the concentration of copper built up in a very short time in all of the pipes. After 6 hr. detention of the water in the red brass pipes a pick-up of 0.68 ppm. of copper was noted. This increased to almost 1 ppm. after a one-day detention period. For longer detention the increase of copper in the water was not as great.

TABLE 1

Increase in Zinc and Copper Concentrations in Water Retained in Red Brass Pipes

Retention Time—*Days*	Zinc—*ppm.*			Copper—*ppm.*		
	Alternating Current	Direct Current	No Current	Alternating Current	Direct Current	No Current
0.25	0.32	0.26	0.16	0.68	0.68	0.68
0.5	0.64	0.58	0.64	0.69	0.59	0.69
1	0.98	0.85	0.88	0.95	0.90	0.93
2	1.17	0.85	0.80	0.45	0.40	0.45
4	0.95	1.10	1.26	0.30	0.30	0.31
8	0.89	1.16	1.16	0.20	0.20	0.30
16	2.31	2.52	2.94	0.32	0.32	0.32
32	5.85	7.53	7.80	0.49	0.49	0.54

The opposite effect was noted with the zinc from these pipes. Starting with a low concentration, the amount of zinc found in the water after 32 days was almost 8 ppm. The process of dezincification is characteristic of brass pipe as zinc is more active than copper in the electrochemical series.

Results of Study

From the point of view of effect on the quality of water in the pipes, the observation of greatest significance is that, under the conditions of the study, no effect of current characteristics could be noted. Copper concentrations followed each other very closely throughout the range of detention periods. The same was true for zinc. It is obvious that if superimposed current had any effect, the concentrations of copper and zinc in the water contained in the pipes carrying currents should be higher than those in the pipe not subjected to any current. Since this increase was not observed, it may be stated that grounding currents of 1.25 amp. on red brass pipe had no effect on New York City water from the Catskill source.

In Table 2 are presented the results of the analyses for copper present in the water retained in the copper pipes. These increases in copper were brought about by the corrosion of the copper pipes. Figure 10 shows the increases in copper concentrations measured in ppm. plotted against the logarithms of detention time.

From this graph it is evident that copper losses sufficient to build up a concentration of over 1 ppm. in the water took place within 6 hr. after the water entered the copper pipes. Further losses were not significant until four days had elapsed, after which there was a gradual increase in copper concentrations in the water.

TABLE 2

Increase in Copper Concentration in Water Retained in Copper Pipes

Retention Time—*Days*	Copper—*ppm.*		
	Alternating Current	Direct Current	No Current
0.25	1.20	1.15	1.15
0.5	1.30	1.35	1.40
1	1.33	1.33	1.32
2	1.05	1.10	1.10
4	1.15	0.95	1.15
8	1.55	1.55	1.45
16	1.85	1.95	1.85
32	2.40	3.20	1.95

For the first sixteen days the pipes subjected to alternating or direct current yielded results almost identical with those obtained in the pipe subjected to no superimposed current. After 32 days the pipes carrying current gave slightly higher results. It may be seen that, under the conditions of the study, the grounding currents had no effect on the quality of the water in the copper pipes.

TABLE 3

Increase in Zinc Concetration in Water Retained in Galvanized-Iron Pipes

Retention Time—*Days*	Zinc—*ppm.*		
	Alternating Current	Direct Current	No Current
0.25	3.54	4.75	3.06
0.5	5.60	7.50	5.23
1	8.25	7.97	7.39
2	8.00	5.33	9.10
4	10.10	6.72	5.60
8	15.70	9.35	13.55
16	10.05	9.50	8.78
32	18.15	39.40	18.15

The loss of zinc from galvanized-iron pipes has been tabulated in Table 3. These results are shown in Fig. 11 where the concentration of zinc has been plotted against detention period for the various current characteristics. Less consistency of results from the various pipes was found with this metal than with the metals in the other experiments. A tendency toward formation of a white flocculant precipitate was noted, making representative sampling somewhat difficult. This was particularly true after a detention period of 32 days, as the results in Fig. 11 will indicate. No consistent difference in zinc concentrations was noted in the pipes carrying current from that carrying no current. Thus, under the conditions of the study, the grounding currents had no effect on the quality of the water in the pipes.

Analyses for iron were also made on the effluent from the galvanized-iron pipes. During the course of the experiments some rusting took place, with the formation of tubercles, but much of the zinc coating remained. Not enough iron was lost by the pipes to increase the concentration of iron in the water to any measurable degree.

TABLE 4

Increase in Lead Concentration in Water Retained in Lead Pipes

Retention Time—*Days*	Lead—*ppm.*		
	Alternating Current	Direct Current	No Current
0.25	0.60	0.65	0.65
0.5	0.75	0.75	0.70
1	0.83	0.92	0.88
2	0.70	0.70	0.90
4	1.10	1.00	1.10
8	1.10	1.20	1.10
16	1.30	1.25	1.45
32	0.90	0.80	1.20

Lead pipes yielded the results shown in Table 4. These have been plotted semi-logarithmically against detention time, as shown in Fig. 12. Results were similar to those obtained with the other pipes in that, under the conditions of the study, no effect of superimposed current was noted. All three pipes gave almost equal concentrations of lead for detention periods ranging from 6 hr. to 32 days.

Summary

Research on the effects of electric grounding was conducted to determine the increase in the concentration of metals in the water contained in pipes subjected to electric grounding. Four types of pipes were used, including red brass, copper, galvanized iron and lead.

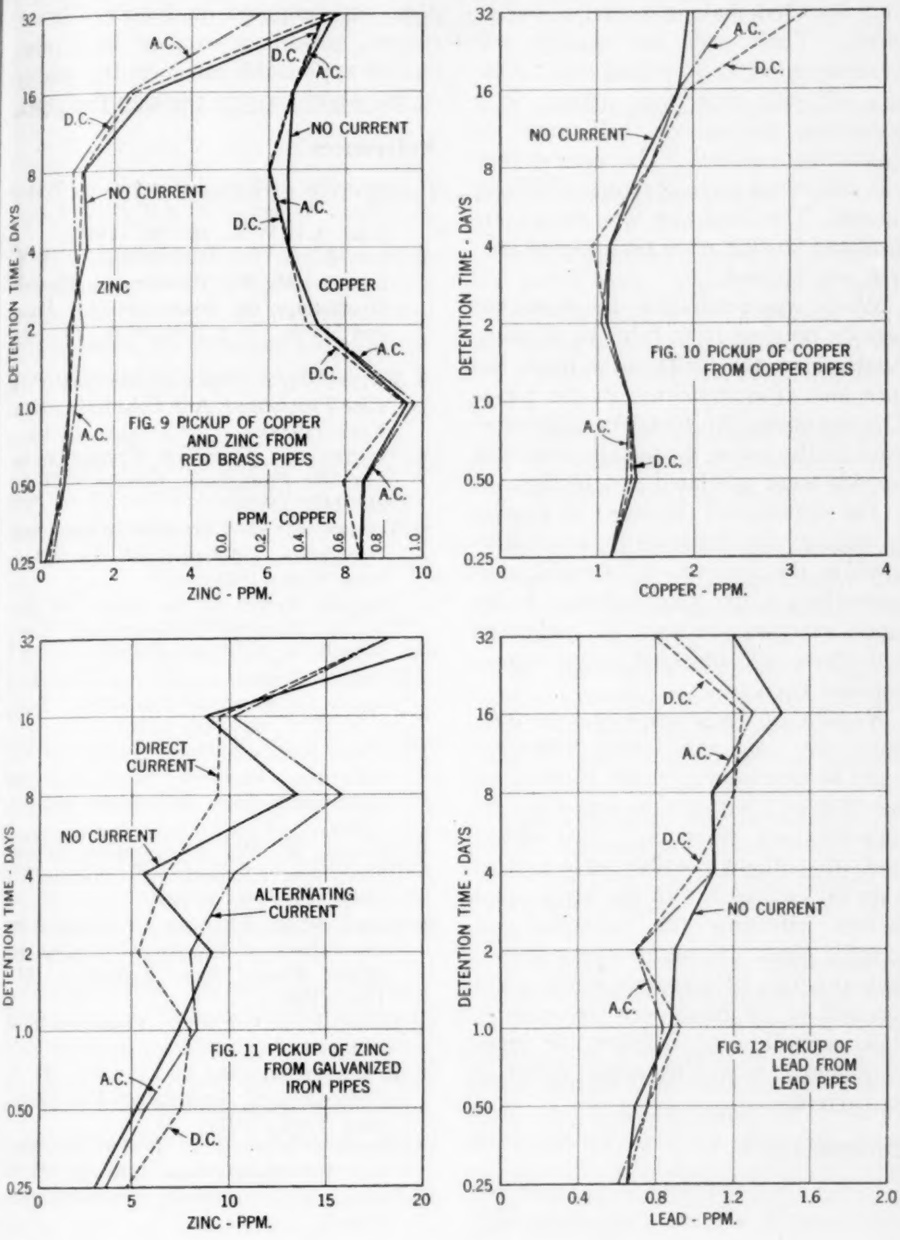
FIG. 9 PICKUP OF COPPER AND ZINC FROM RED BRASS PIPES
DETENTION TIME - DAYS
32
16
8
4
2
1.0
0.50
0.25
ZINC - PPM.
0
2
4
6
8
10
PPM. COPPER
0.0
0.2
0.4
0.6
0.8
1.0
A.C.
D.C.
NO CURRENT
ZINC
COPPER
FIG. 10 PICKUP OF COPPER FROM COPPER PIPES
COPPER - PPM.
1
2
3
4
FIG. 11 PICKUP OF ZINC FROM GALVANIZED IRON PIPES
DIRECT CURRENT
ALTERNATING CURRENT
5
10
15
20
FIG. 12 PICKUP OF LEAD FROM LEAD PIPES
LEAD - PPM.
0.4
0.8
1.2
1.6
2.0

Figs. 9–12

Three lengths of each type of pipe were installed, making a total of twelve pipes. These ran horizontally and were mounted on a vertical wall. One pipe of each type was subject to a grounding current of 1.25 amp. of alternating current. The second pipe was subjected to 1.25 amp. of direct current. The third pipe was completely insulated so that no superimposed current was applied.

Water was retained in the pipes for periods ranging from 6 hr. to 32 days. Analyses of the water were made before and after retention in the pipes. The increases in metallic concentrations in the water during the retention periods were tabulated and plotted.

The criterion of the effect of electric grounding was indicated by any differences in the increases of metallic concentrations in the water retained in the pipes carrying current as compared with those not subjected to any superimposed current.

Results of these experiments indicated that no appreciable difference could be determined in the increase or decrease of metallic concentrations by superimposed currents. Any differences that might possibly have existed were far outweighed by the many other factors effecting the corrosion of metallic pipes. Concentrations of metallic products of corrosion in the water retained in the pipes were remarkably close regardless of whether the pipes were subjected to alternating, direct or no current.

Conclusions

Under the conditions established for this research, electric grounding with an alternating or direct current of 1.25 amp. superimposed on ¾-in. red brass, copper, galvanized-iron or lead pipes had no appreciable effect on the quality of the water passing through the pipes.

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A Checklist for the Water Works Executive

THE Committee on Water and Sewage Works Development has been promoting, through all means reasonably possible, the *planning now* for water works construction after the war is over. It holds this principle to be beyond dispute:

"Every city in North America is entitled to have—and with good management is able to pay for—an adequate, safe and satisfactory water supply . . ."

There is a corollary to that idea: The water supply of any city is as good as the citizens want it to be and as good as the city's executives feel themselves obligated to provide for the citizens.

That sense of obligation which a water works executive has, comes in part from the current of public opinion in the city; and in part from his own pride in, and ambition for, the city that he serves.

Improvement of any city's water works system is unlikely if the superintendent or manager fails to fight for it. This is one job of *starting* that cannot be left to anyone else. Either the water works man sees for himself what his plant needs and then starts promoting that improvement, or the water system gets no improvement.

How does a man know what his plant needs? There is really no answer for that that anyone can give better than the man who runs it.

So a checklist is provided here for any water works man to use, if today—near the middle of 1944—he feels any doubt concerning the point in his city's water system that needs improvement.

He should use the checklist to support his presentation of a water works improvement program to the city executives.

He can have for the asking a copy of "Blueprint Now" to supplement his ideas to the mayor or the council. He can obtain consulting engineers' counsel or equipment salesman's suggestions. Any of these things he can get from someone else. He must be the "starter" and the checklist that follows will serve as the "go" signal.

With regard to the possibilities of federal financial assistance, we believe the recent statement of Representative Lanham of Texas is prophetic. He stated:

"The states and cities must realize that the federal government will not take this job. We must get the word out to those cities with surpluses that they must do their own planning and work and must not wait for Federal aid which they will not get. Send that message to the states and cities. The cities themselves must finance their own planning."

For the Committee on Water & Sewage Works Development,

HARRY E. JORDAN,
Secretary

A. General

1. Quantity—Raw Water
   - (a) Is supply ample for general domestic and ordinary industrial requirements NOW?
   - (b) Have drought periods caused curtailment?
   - (c) Is supply expected to be sufficient for the demands of the next 10 yr.?
2. Quality—Raw Water
   - (a) Is watershed relatively clean?
   - (b) Is pollutional load slight?
   - (c) Is pollutional load heavy?
     - (1) Industrial wastes
     - (2) Sewage
   - (d) Are chemical characteristics:
     - (1) Soft (below 100 ppm.)
     - (2) Hard
     - (3) Highly colored
     - (4) Corrosive?
   - (e) Are algae growths a problem?
3. Sanitary Control
   - (a) Does water utility control:
     - (1) Watershed
     - (2) Shore line
     - (3) Uses of impounded waters?

B. Source of Supply

1. Creek or River (Surface Supply)
   - (a) Quantity
     - (1) Is runoff becoming more "flashy"?
     - (2) Is channel or other storage necessary?
     - (3) Is ice formation a problem?
     - (4) Are low water periods becoming longer?
     - (5) Are discharge measurements kept?
     - (6) Do flood control impoundings regulate stream flow?
   - (b) Quality
     - (1) Are chemical characteristics changing?
     - (2) Are high turbidities a problem?
     - (3) Are industrial wastes affecting operation?
     - (4) Is bacterial load increasing?
2. Lake or Impounded Supply
   - (a) Quantity
     - (1) Has level been receding for some years?
     - (2) Has silting reduced capacity?
     - (3) Is runoff into lake diminishing?
     - (4) Are rainfall and lake level records kept?
   - (b) Quality
     - (1) Are algae growths troublesome?
     - (2) Is lake shore owned by city?
     - (3) Are industrial wastes in watershed controlled by city?
3. Wells or Spring (Ground Water) Supply
   - (a) Quantity
     - (1) Is ground water table dropping?
     - (2) Is yield diminishing?
     - (3) Are "spare" wells or an auxiliary supply available?
     - (4) Have "long-time" observations been kept as to ground water changes?
     - (5) Is drilling of wells for industrial or air con-

ditioning uses regulated by city?

(6) Are discharge records of each well kept?

(b) Quality

(1) Is objectionable mineral content, if present, as iron, fluorine, manganese increasing?

(2) Are objectionable gases (H_2S, CO_2) present?

(3) Has a chemical record of wells, etc., been kept for a period of years?

C. Raw Water Equipment

1. Is intake structure satisfactory?
2. Are there "duplicate" or spare raw water screens?
3. Is there an auxiliary source of power?
4. Are spare motors, pumps, etc. available?
5. Are "ice" problems frequent in winter?
6. Can water be taken from different levels?
7. Is raw water measured?
8. Are pumps designed for operating head conditions?
9. Is the raw water line to plant in duplicate?

D. Treatment Works

1. Does plant have ample "reserve capacity" at time of peak demands?
2. Would failure of any single unit, pipeline, valve, etc., throw the entire plant out of service?
3. Is the State Health Department satisfied with the (a) physical make-up of plant, (b) operating personnel, (c) records of operation?
4. Do you consider the plant "flexible" as to operation?
5. Can the following plant processes be improved or made more economical by new construction, equipment, etc:
   (a) Coagulation (including softening) of water
   (b) Sedimentation
   (c) Filters
   (d) Washing of filters—including sewer line
   (e) Clear water storage
   (f) Sterilization
   (g) Measurement of plant process water, etc.
   (h) Corrosion control?
6. Does high service pumping station have:
   (a) Satisfactory number of proper sized units
   (b) Duplicate source of power
   (c) Valve arrangements satisfactory to Fire Underwriters
   (d) Satisfactory measuring devices for:
      (1) Electricity used
      (2) Water delivered to distribution system?
7. Are "plans" of plant and improvements, etc., thereto kept up-to-date?
8. Are grounds and plant appurtenances kept orderly and neat?

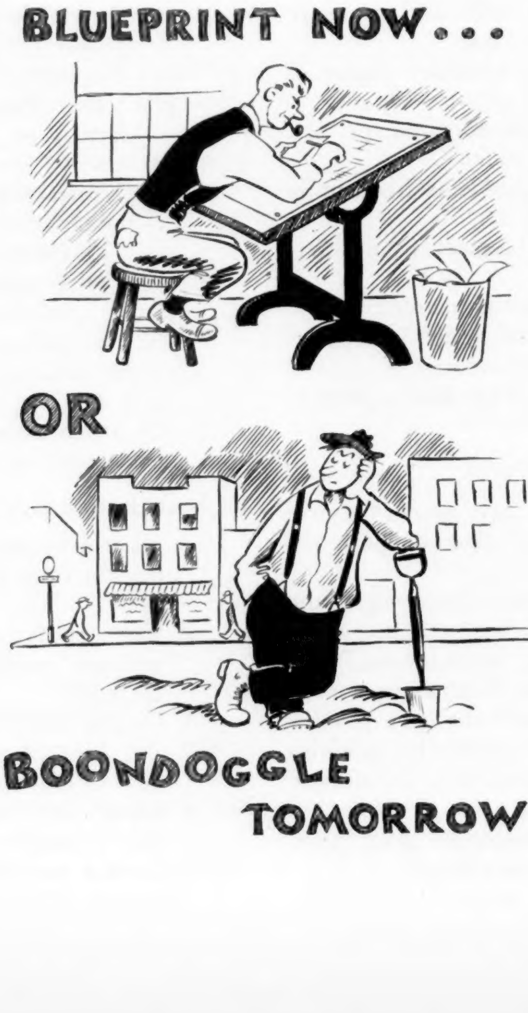
E. Distribution System

1. Have you two or more main feeders from plant to distribution?
2. Can fire flows be distributed without undue pressure increases?
3. Do you utilize elevated storage?
   (a) Is it adequate?
   (b) Is it properly located?
4. Have you "standardized" on (a) Valves, (b) Hydrants, (c) Service meters?

5. Are service meters periodically checked for accuracy?
6. Are there many "flat" rates?
7. Is the "unaccounted for" water loss less than 15 per cent?
8. Are "dead ends" numerous?
9. Have you made a "cross-connection" survey of your system?
10. Are ample repair parts, spare pipe, etc. carried in stock?
11. Have you investigated pipeline corrision in your system?
12. Have you "correct" distribution system records showing: (a) Location and size of mains, (b) Valves, (c) Hydrants?

F. Business—Management

1. Is your record keeping equipment modern?
2. Is billing equipment modern?
3. Do you "adjust" unduly large bills?
4. Are your "contact employees" informed?



Utilities Commodity Tax

THE city of Columbus, Ohio, recently passed a new tax, known as a utilities commodity tax, which should be of interest to all utilities operators. Portions of the Ordinance are quoted below:

"AN ORDINANCE No. 120–44 To provide for the levying of a utilities commodity tax and to repeal ordinance No. 84–44, passed February 21, 1944.

"Whereas, an emergency exists in the usual daily operation in the various divisions in the several departments of the city of Columbus, in that it is immediately necessary to provide funds for the operation of said divisions and for the preservation of the pubilc property, health and safety of the people of the city of Columbus; now, therefore,

"Be it ordained by the council of the city of Columbus:

"Section 1. For the purposes of this ordinance, and unless otherwise required by the context, the words, "City Treasurer" shall mean the city treasurer of the city of Columbus, Ohio; and the words, "City Auditor" shall mean the city auditor of the city of Columbus, Ohio; and the word, "person" shall include individuals, firms, partnerships, associations, corporations and combinations of individuals of whatever form and character.

"Sec. 2. That for the purpose of providing revenues for the general revenue fund of the city of Columbus for the calendar year ending December 31, 1944, in addition to those raised from general property taxes permitted under the constitutional limitations and from other sources, for the support of local governmental functions, there is hereby levied for the calendar year 1944:

(a) A tax of five per centum computed on the net rate charged for natural gas consumed in the city of Columbus;

(b) A tax of five per centum computed on the net rate charged for electrical energy used in the city of Columbus;

(c) A tax of five per centum computed on the net rate charged for 'local service and equipment' to telephone subscribers within the city of Columbus.

(d) A tax of five per centum computed on the net rate charged for water furnished in the city of Columbus.

"The tax hereby levied shall not apply when the consumer or user is the state of Ohio or the United States Government.

"Sec. 3. Each and every person, including the city of Columbus, selling, furnishing or delivering any of the commodities for or on which a tax is levied by section 2 hereof, and for which a charge is made, shall in each and every bill or statement rendered therefor after the first day of April, 1944, set forth an item for said tax either as a separate item or in connection with any other tax on said bill, carrying out the amount thereof and include the same in the total of said bill or statement so rendered, and collect said tax from the consumer or payer of said bill or statement at the time of the payment thereof.

"Sec. 4. Every person receiving any payment on bills or statements taxable under this ordinance shall, on or before the 15th day of each calendar month, make a return in duplicate under oath to the city auditor in such form as the city auditor may prescribe, showing the aggregate amount of taxable payments for such bills or statements collected during the preceding calendar month, the amount of tax hereby imposed and collected on the same, and such other facts and information as the city auditor may require, on the form of return prescribed by him; one copy of such return shall be for the use of the city auditor and the other shall be filed by the city auditor in the office of the city treasurer.

"Each person making such return shall, at the time of making the same, pay the amount of taxes shown as due thereon to the city treasurer who shall credit the same to the general fund."

There are several additional sections of the Ordinance, but they refer entirely to administrative details within the city. Harry E. Jordan, *Secretary*

WPB U-1 Supplementary Orders

THE U-1 Series of supplementary orders was amended on April 6, 1944. Most of the changes relate to conditions in the electric utility field. In order U-1-f [*see* p. 251 Feb., 1944 JOURNAL] certain changes have been made which affect water utilities:

Paragraph (b) (3) has been deleted from the order. The effect of this change is to permit extensions of service to all classes of industrial and commercial consumers, including such consumers as wholesale and retail establishments, physicians' offices, and restaurants, which were not previously provided for in the order. Please refer to section B I and B II of the Utilities Construction Standards for information as to the materials that may be used in the construction of extensions to all classes of consumers.

The Utilities Construction Standards have been revised. The complicated tests for determining the quantities and kinds of pipe used in extensions of service under U-1-f are no longer applicable. A total of 350 ft. of pipe may be used in any one domestic extension (500 ft. for certain commercial and industrial extensions, no footage limit as to others) irrespective of the kind of pipe proposed to be used, and of whether the extension is of main or of service. The one exception to this rule is where copper or copper base alloy pipe or tubing is to be used. A recent amendment to Order M-9-c-4, has released copper pipe or tubing for use in extensions of service of this kind, provided that the pipe or tubing was in inventory prior to January 1, 1944. Order U-1-f limits the length of such pipe or tubing for a domestic installation of gas or water service to the amount necessary to reach from the main to the curb stop or consumer's property line. Of course the length of copper pipe or tubing used must be included in calculation of the footage limitation on total length . . .

Utilities are reminded that, while new copper or brass pipe may not be purchased for service extensions from commercial suppliers, the allotment number U-9 or Order U-1 may be used to purchase such pipe from the inventory of another utility.

Abstracts of Water Works Literature

Key: In the reference to the publication in which the abstracted article appears, **34:** 412 (Mar. '42) indicates volume 34, page 412, issue dated March 1942. If the publication is paged by the issue, **34:** 3: 56 (Mar. '42) indicates volume 34, number 3, page 56, issue dated March 1942. Initials following an abstract indicate reproduction, by permission, from periodicals, as follows: *B.H.—Bulletin of Hygiene* (*British*); *C.A.—Chemical Abstracts; P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research* (*British*); *I.M.—Institute of Metals* (*British*).

WARTIME WATER WORKS PROBLEMS

Reducing Government Questionnaires Through Utility Subcommittees. David J. Guy. Edison Elec. Inst. Bul. (Apr. '44). Advisory subcommittees on govt. questionnaires to pub. utils. organized slightly more than year ago. These committees at work, on voluntary basis and in advisory capac., with view to reducing to min. time and labor their particular industry must devote to govt. questionnaires. Substantial results accomplished, effects of which will not terminate with war emergency, but continue as permanent saving. Since only advisory in character, subcommittees operate largely on own volition and without restraint. Util. industries will be interested to learn something of how these improvements being achieved; who initiates changes in reporting requirements of fed. agencies; and what mechanism and procedure is. Intended to convey to industry some conception of little-known activity and opportunity still available for accomplishing some much needed curtailments and revisions in reporting practices. *Origin of Control Over Data Collecting.* Almost every govtl. function needs industry data as basis for detn. of policies or as tools for policy effectuation. Fed. govt. has long recognized need for coordination of statistical activities of fed. agencies. On Dec. 24, '42, President approved Public Law 831 of 77th Congress, known as Federal Reports Act of '42. In effect, law states that information which may be needed by various fed. agencies should be obtained with min. burden upon business enterprises (especially small business enterprises) and other persons required to furnish such information, and at min. cost to govt., that all unnecessary duplication of efforts in obtaining such information through use of reports, questionnaires and other such methods should be elimd. as rapidly as practicable; and information collected and tabulated by any fed. agency should, insofar as is expedient, be tabulated in manner to maximize usefulness of information to other fed. agencies and the public. Act more than declaration of policy. Makes it mandatory upon all fed. agencies to "clear" in advance with Bur. of Budget before they embark upon any data-collecting venture. Moreover, by terms of Act, and more specifically by provisions of Regulation A, collection of information made broad so as to include application forms, admin. forms, questionnaires, telegraphic requests and other similar devices for collection of data when 10 or more respondents involved. Thus, regulations embrace priority applications, questionnaires used single time for research purpose, annual or other report forms used for admin. purposes by regulatory agencies, telegraphic or telephonic requests for a statistic, as well as record-keeping requirements, including systems of accts. and systems of classification to be used for collection of information. Just before President's approval of Act, Harold D. Smith, Director of Bur. of Budget, wrote to number of natl. organizations requesting "counsel of those who are untimately aware of problems to which govtl. requests for information give rise in business offices." Businessmen indorse idea that govt. can no more operate successfully in vacuum of facts than can business;

each must act on basis of observed facts rather than on unsupported hunches. Budget Bur.'s invitation to business to counsel with it was "in order to assist in evalg. necessity for questionnaires which it must clear, and to weigh such necessity in balance which requests impose upon business and industry." Committee formed by participating assns., organized in March '43, known as Advisory Committee on Government Questionnaires. Maintains offices in Washington in co-operation with Bur. of Budget. Functions exclusively advisory to Budget Bur. and personnel appointed by and responsible only to business community. Operates largely through subcommittees, each organized along well-defined lines. *Organization of Utility Industry Subcommittees.* Pub. util. industry, including gas, elec. and water utils., and both publicly and privately owned parts thereof, among first participants in this activity. Advisory Committee gave consideration to questionnaire problems of util. industry at its Feb. 9, '43, meeting when it authorized exploratory meeting to which were invited representatives of all natl. assns. in util. industry. Group met in New York City March 19, '43. Decision made to organize 3 subcommittees, each to devote itself to separable problem: (1) Financial and Accounting, (2) Materials Controls, and (3) Engineering and Facilities. Each committee active in own field and amt. of activity directly reflected in two important directions—one curative and other preventative. Material and substantial improvement in both questionnaires and reporting requirements, some of long standing, and very existence of subcommittees has given pause to drafters of questionnaires. Financial and Accounting Subcommittee very active and result producing. Has held number of meetings and during intervening periods members extremely active in research activities concerning projects which committee had undertaken. Materials and Controls Subcommittee less formal in organization and operations but equally as effective. This group has dealt exclusively and most successfully with orders, regulations and forms of WPB (OWI) and other war agencies, and active in dealing with questionnaire problem at its source. On one assignment alone, estd. that reporting requirement initiated by fed. agency and disapproved by Budget Bur. involved saving to industry of 840,000 man-hr. Engineering and Facilities Subcommittee only recently activated. *Control Air-Tight and Fool-Proof.* Effectiveness of Budget Bur.'s review process and mechanism for assigning approval numbers and expiration dates affords unparalleled opportunity to business and industry to be heard during formative stages of new questionnaires, or when existing forms are re-examd. Regulations require that every authorized fed. form or other data request must bear Budget Bur. approval number and, in most cases, expiration date. *Whenever form is received without approval number thereon, fair presumption that form has not been reviewed or authorized.* Such cases should be reported for attention or advice to either Budget Bur. or advisory subcommittee concerned. Expiration dates mean forms will be obsolete beyond that date unless again submitted and approved, in which event new date assigned. Date serves as advice to respondents, not only as to life of temporary or short-term forms, but as to date in advance of which review of form again undertaken. Frequently found that form designed to serve well-defined purpose remained in effect long after original need ceased to exist. On other occasions, even though usefulness of original need continued, refinements, modifications and clarifications seemed desirable. Reexamns. at periodic intervals thus possible and respondents to govtl. requests for information urged by Bur. of Budget to make their comments known. No review of util. subcommittee activities complete without acknowledgment of several prime-movers in this economy effort. For Budget Bur., Dr. Stuart A. Rice, Asst. Director in Charge of Statistical Stds., and his able asst., William R. Leonard, have given freely of their time and talents to industry's problems. Peyton Stapp, Clearance Officer, Div. of Statistical Stds., and David E. Cohn, Div.'s utility specialist, have rendered invaluable assistance. William J. Donald, Chairman, Advisory Committee; and Russell W. Schneider, its Exec. Secy., have shown special interest in questionnaire activities relating to utils. [*Note:* For public water supply industry, H. D. McDowell, Secy., American Water Works & Elec. Co., serves on Financial and Accounting Subcommittee; and Harry E. Jordan, Secy., A.W.W.A., serves on Engineering and Facilities, and Materials and Controls Subcommittees.]—*Ed.*

Selective Service Crisis. ANON. Chem. & Eng. News **21:** 1420 (Sept. 10, '43). Draft-

ing of fathers complicates retention of technical men for production front. Set-up of Selective Service System enables deferment of necessary and non-replaceable chemists and chem. engrs. Frequent mistakes in procedure: failure to appreciate shortage when prepg. Manning Tables and Replacement Schedules, failure to record efforts to locate replacements through U.S. Employment Service, failure to maint. contact with Occupational Adviser of State Selective Service Headquarters, failure to contact local board well ahead of expiration of 6 mo. deferment—5 weeks recommended—and failure to follow through appeal procedure to limit. Natl. Roster may function at 2 levels, i.e., local board should be asked to refer there if any doubt of classification exists; employer or employee, on receipt of induction notice, should immediately communicate with Natl. Roster, who may ask temporary stay of induction to allow review. By these means leakage of properly qualified chemists and chem. engrs. from production into combat forces should be stopped completely.—*A. A. Hirsch.*

Water and War Production. C. V. Youngquist. Ohio State Eng. Exptl. Station Bul. **14**: 21 (Oct. '42). Water needed in almost every phase of war production effort. Reduction of fuel consumption from 7 lb./kwh. of coal to less than 1 lb. possible largely through increased use of cooling water. Nearly 80 gal. required per kwh. Water essential to steel mfg. Amts. to 65,000 gal. per finished ton. Powd. for shells and guns requires over 100 gal./lb. of powd. For each gal. of aviation fuel 25 gal. of condensing water needed. Quant. of water used in 1000 plane raid 2½ mil.gal. for each hr. of raid. Production of 1 lb. of aluminum uses 960 gal. condensing water. War production effort has emphasized that water vital material.—*H. E. Babbitt.*

Substitutes and Alternatives Used in Wartime Construction and Operation. W. Clarke Gardner. Md.-Del. Water & Sew. Assn. 17th Ann. Conf. ('43). Water supplied to Salisbury Water Works from five 18″ id. concrete casing wells and two 24″ od. by 12″ id. gravel pack wells, 48–60′ deep. Combined capac., 6.4 mgd. or 4500 gpm.; high service elec.-driven pumps of 5000 gpm. capac.; 160-kvd. diesel standby unit; underground storage capac. 550,000 gal.; combined storage capac. of 3 elevated tanks, 580,000 gal.; and distr. system contains 44.88 mi. of 4–20″ c-i. mains, 750 gate valves and 3405 service connections. Problem: alternate water supply to meet bombed conditions. Protection through concrete burster slabs and sand bags doubtful and cost excessive. Previous test wells and existing indus. supplies suggested promising alternate in 5 or 6 10″ casing wells, each with 20′ strainer, at fixed locations to yield 2000 and 2500 gpm. This capac., plus underground and elevated storage, allow nearly 300 gpd. per capita for domestic and fire fighting use. Because static water level here avgs. 20′ below avg. ground el. plus 25′ above sea level, concealed underground stations utilizing horizontal centrifugal pumps employing "flooded suctions" possible. These units connectable to existing water system with belt-driven used auto engines supplying power at pump. 20 hp. engines could discharge 400 gpm. against total 150′ head, maintg. 40 psi. curb pressure. *Advantages:* Exact location of units undeterminable by enemy bombers; supply safe for consumers; accessible through manhole vaults or tunnels; "flooded suctions" obviate pump priming; 5 or 6 units pumping into 45 mi. of distr. system at scattered points would assure min. supply with satisfactory pressure; pumps would function despite power failure; venting exhaust gases possible through pipes to surface; nearby bomb explosions unlikely to affect station depth; gasoline storage provided in ground tanks; economical first cost—cheaper than providing full protection to existing plant and equip.; used auto engines obviate need for pump motors and elim. priority problems; stations small, of brick or plain concrete, underground.—*Ralph E. Noble.*

Problems of the Sanitary Engineer Arising From Enemy Air Attacks. Gordon S. McDonald. Surveyor (Br.) **102**: 335 (Aug. 13, '43). Bomb explosion may cause comparatively shallow crater but in many cases sewers and other mains badly shaken even at some depth. Heavy clay will carry shock to far greater distances than sand and gravel. Damage to sub-soil and services therein considerable. Phenomenon experienced great deal where roads heavily paved, such as in case of tramways, shock tending to spread laterally rather than vertically. Blast effects frequently cause trouble for considerable distance from crater where effects travel up various drain connections. Quants. of gravel and other debris frequently blown into

exposed ends of broken sewer or water main and complete blockage may result at point away from crater. Apart from damages to services, another important factor is blockage of roadways by debris from shattered bldgs. which hamper engr.'s access to particular problems. If water cut off from inhabitants very unsanitary conditions soon prevalent. Lavatory accommodations become choked and when water restored drains carry excessive quant. of detritus which frequently causes blockages. Alternative accommodations of latrines and trenches in neighboring parks and open spaces not popular. Where heavy damage to services has taken place over wide areas, measures taken to supply water by means of conveyances. Work of san. engr. when area subjected to enemy attack, divided into 3 phases: First phase is properly organized plan of campaign. Second phase covers period of actual attack. Here work largely concerned with collecting information and taking such temporary measures as he is able during attack. Must do utmost to insure that water supplies for fire fighting available. Major portion of work comes in third phase after raid is over. Usually as long as outlet from sewer functioning, no poln. from sewer to water main. First object is to clear outlet of sewer. Temporary repairs not looked upon with any favor. Only occasions when temporary works has to be resorted to are when it is vitally important to obtain immediate access to, e.g., a factory. Reconstr. of sewers or water mains carried out on normal lines as materials and labor become available. Experienced men can tell by inserting crowbar in open end of pipe whether there is movement in next joint. Few failures occur after repairs carried out using such rule-of-thumb tests of experienced laborers. Mutual support now established between neighboring dists. throughout any particular region. After gen. repair work put in hand before engr. can recharge water mains has to isolate private pipe work that may have suffered damage. In indus. area difficult to handle. If possible, discharged mains should be sterilized before recharging. 3 safeguards against danger from poln. of water supply: (1) mains should be sterilized; (2) water should receive dose of chlorine at rate of 1 ppm.; and (3) householders should be warned that water should be boiled. Doses aimed at (in sterilizing mains) are of order of 25 ppm. chlorine and contact period of 12 hr. Bakers should be advised to provide activated carbon filters for dechlorination of water for bread making. Proper water supply system should be planned on "cobweb" principle, having arteries leading to center of area, with circumferential connecting links. In large bldgs. and even in dwellings, stop cocks should be provided and easily accessible. In some areas use being made of wells in "blitzed" factories. In well-planned areas proposals will be considered to segregate various systems so that in event of damage to mains, poln. of water supply from sewers, flooding of gas mains from water mains, either elimd. or restricted. —*H. E. Babbitt.*

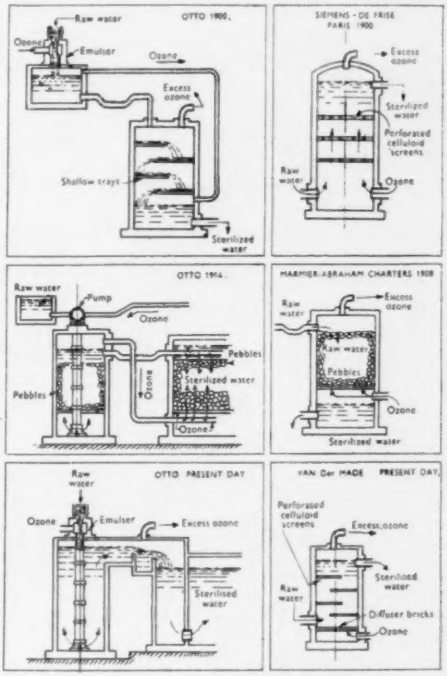
The Detection and Analysis of Arsenic in Water Contaminated With Chemical Warfare Agents. C. C. Rucchoft, O. R. Placak & Stuart Schott. Pub. Health Rpts. **58:** 1761 (Dec. 3, '43). Arsenical contamn. one of possible dangers to water supplies in surprise attacks of modern chem. warfare. Not readily detd. quantitatively by ordinary methods. Org. arsenicals must be decomposed and oxidized for quant. detn. in low but toxic concns. likely to occur. More important compds. include: methyldichlorarsine, ethyldichlorarsine, Lewisite-B chlorovinyldichlorarsine, phenyldichlorarsine, diphenylchlorarsine, Adamsite phenylarsazine, chloride diphenylcyanoarsine and diphenlyaminocyanoarsine. First 3 are alipathic arsines and vesicants. Because appearance and odor of water contg. any of these undependable indication of toxic contamn., anal. for arsenic necessary if water suspected. Possible change in pH should be watched for as indicating contamn. by one or more soluble arsenicals and, if found, tested for arsenic immediately. Other As compds. discussed. In emergencies and if other supplies unavailable, suggest permitting As concns. up to 1–2 ppm. for several days; and concns. as high as 5 ppm. for 1 day. Prepn. of sample, app. and anal. procedure fully detailed.—*Ralph E. Noble.*

Deodorizing Water in Army Camps at the Front. A. G. Polyakov, O. G. Zhdanova & M. F. Asmolova. Sovet. Zdravookhranenie Turkmenii (U.S.S.R) *No.* 2: 22 ('42). Odors due to putrefaction of plant material in water can be partially removed by: (1) adding 3–5 drops of 1 : 1000 $KMnO_4$ soln. per 100 ml. of water, letting stand 1 hr., and treating with NaOH soln., then with $Ca(OH)_2$ soln. to alk. reaction; or (2) boiling water

with permanganate for 15 min. (adding $KMnO_4$ soln. dropwise until pink color persists) and on cooling adding $Ca(OH)_2$ soln. until ppt. of MnO_2 appears. Odor from putrefaction of animal waste matter cannot be removed by permanganate. Powd. charcoal (1 g./l. of water) completely removes odors of plant origin in 15–20 min.; animal odors not completely elimd. Other methods found unsatisfactory.—*C.A.*

OZONE TREATMENT

The Treatment of Water by Ozone. M. T. B. Whitson. J. Inst. Civ. Engrs. (Br.) **21**: 83 (Dec. '43). Among objections to use of ozone following may be mentioned: production by electrifying air difficult and costly; cannot be obtained pure; only small percentage of air treated can be made into ozone, so that comparatively large vols. of air have to be dealt with. Greatest objection seems to be its insolubility. Readily destroys color and microbes and turns into oxygen so that nothing of it remains in water. Discovered by Van Marum in 1785 and first applied to sterilization of water by Schönbein at Metz in 1840. Paris Exhibition of 1900 had on view ozone generator used. for purif. of water at Lille. In '06 Otto received contract to ozonize $5\frac{1}{4}$ mgd. (Imp.) at Nice, and Paris authorities decided that ozonization gave best results of sterilizing filtered Marne R. water. Prior to present war, position was: France, 90 installations on public water supplies; Italy, 14; Belgium, 5; England, 4; Rumania, 3; U.S., 2; Russia, 1. Only two types of ozone producers in use today on commercial scale. Both adaptations of Von Siemen's exptl. ozonizer of 1857 and depend on discharge of high-voltage electricity between stationary electrodes. Two std. plants operating in Great Britain are: (1) Van der Made type and (2) Otto type. In Van der Made type ozone generated by discharge of high-voltage electricity between cylindrical metal electrode and glass cylinder. Previously dried air drawn in at one end of ozonizer tube and part of oxygen in air converted to ozone as it passes through high-tension discharge. App. water cooled. Ozonized air compressed and discharged through diffuser bricks into bottom of mixing tower where it passes upwards through water to be treated. Otto process differs in method of generating ozone and mixing. Discharge of high-voltage electricity takes place between glass plate dielectrics backed with water-cooled metal electrodes. Air blown through dessicator to ozonizing chamber which contains battery of electrodes and then passes between dielectrics to central port. Ozonized air conveyed by porcelain pipes to emulser where it meets water to be treated. Partial vacuum created at neck sucks ozone into water. "Emulsion" thus formed passes down porcelain pipe into chamber where mixing process continued. Ozone improves bact., chem. and phys.



properties of water. Can remove 50% color and majority of tastes. Does not provoke taste and odor difficulties in distr. system. Water palatable and pleasent to look at. Criticism based on cost and no residual ozone carried in mains to deal with chance contamn. Cost at Ashton avgs. 0.25*d* per 1000 gal. (Imp.). This includes capital and interest charges, elec. energy at 0.5*d* per unit, stores,

maint., renewals and insurance. Energy used at large no. of French plants: Nice, Avignon and Vittel, 45 w. per 1000 gal. (Imp.); Paris and Toulon, 55; Ashton (England), 64; Nancy, 68; Brest, 90. In many cases ozone could supplant some part of purif. system with consequent reduction in over-all cost. Ashton plant (Otto type) typical of French practice and capable of ozonizing 60,000 gal. (Imp.) per hr. Results show pathogenic bacteria most readily elimd. Dosages incapable of effecting any great reduction in non-pathogens sufficient to reduce *Esch. coli* count to nil. Chemically water remained practically unchanged except for oxygen absorbed (in 4 hr. at 27° C.) where reduction is about 50%. Spectacular property is power to reduce color. For present purposes taste and odor defined as "something which water consumer complains about." On this basis ozonization has proved successful at Ashton. Chief conclusions from exptl. work: (1) ozonization should never be attempted with waters subject to heavy algal growths without prior treatment for their removal and (2) Moorland waters, which contain few algal types, may be ozonized direct.—*H. E. Babbitt.*

The Boxley Works of the Maidstone Water Works Company. CHARLES H. HARDEN. Wtr. & Wtr. Eng. (Br.) **46:** 409 (Oct. '43). Two distinct water-bearing formations tapped at same site. Water drawn from Middle Chalk and Lower Grey Chalk by well and adit sited 500 yd. north of toe of chalk outcrop. Drawn also from beds of Lower Greensands by boring sunk through base of chalk well and intervening Gault clay. Chalk water comparatively soft, having hardness of 14.6° Clark, of which 4° permanent. Greensand water chalybeate with total hardness about 7° Clark. Ests. of yields were 437 mil.gal. (Imp.) per annum from chalk and 113 mil.gal (Imp.) from greensands. Well 247′ deep varying between 10′ and 12½′ id. Main adit, commencing from well at depth of approx. 200′, lined with 6′ diam. c-i. rings for first 700′. Remainder unlined. Total length, 3838′. Drilled well 548′ deep varying between 21″ and 32″ in diam. Permanent works comprise: (1) pumping station, (2) service reservoir, (3) 15″ main, and (4) 2 pairs of houses for station staff. Duplicate well pumps to raise chalk water and one pump in borehole to raise greensand water main items of pumping plant. Pumps raise water in one lift through respective treatment plants to service reservoir behind station. 2 small booster pumps installed. Slip-ring induction motor used for driving well and borehole pumps. Chalk pumps deliver water through 12″ Venturi meter to ozone room from which two 9″ mains lead into ozone contact tank. Ozonized water passes to service reservoir. Greensand pump delivers water through deferrization plant. Treated water mixes with ozonized water going into reservoir. Ozonized water has, at this stage, sufficient ozone entrained in it to deal with any possible poln. of greensand water. Accessories to pumping plant: 16-ton overhead crane, electrically operated; switchboard; recorder panel; and water level indicators. Maidstone has large food-producing factories and breweries and residual chlorine would affect mfg. processes. Ozonization adopted partly because of cheap rate offered, partly because water had low oxygen absorbed characteristic, and partly as pioneer step in view of small number of ozone installations in country. Paterson process adopted. Ozonized air introduced into water at 2 injectors. Mains discharge through 2 slotted asbestos cement diffuser pipes at bottom of ozone contact tank, roughly 12′ x 12′ in plan, and 12′ high, capac. just over 9000 gal. (Imp.). Ozonized air causes considerable turbulence in sterilizer, thus thoroughly mixed with water. First item in process is dessication of air to be ozonized. Done by silica gel. App. consists of 2 chambers. Air drawn to ozonizers through one while other, previously used to dessicate air, being dried or "reactivated." Each chamber contains sufficient gel for period of 4 hr. Silica gel activated by elec. heaters. Dried air passes through water-cooled jacket to ozonizing cells. These consist of 5 batteries each of 18 water-cooled glass tubes. High proportion of oxygen converted to ozone. Primary input to transformer is single phase, 50 cycles at 230 v. Output from 5500 to 8500 v. Greensand water contains on avg. 7.5 ppm. iron as Fe and 82 ppm. free CO_2. Room not available for treating water by open aeration. Water first passes through 3 sand settlers with upward veloc. of just over 1 fpm. Settlers have hopper bottoms from which sand washed once monthly. Water passes into filters, each with capac. of 5000 gal. (Imp.) per hr. Filtering media consist of three 4″ layers graded gravel, 12″ layer of sand, 6″ layer of Polarite, and further top layer of sand. Polarite assists removal of iron by oxidation

and catalytic action. Filtering rate equiv. to 100 gal. (Imp.) per hr. per sq.ft. Topmost 2′ of filter filled with air maintd. at pressure about 35′ equiv. head. Proportion of oxygen in air dissolved in water and oxidation of unstable bicarbonate of iron takes place, assisted by Polarite. Outlets fitted with "modules" which can be set to control automatically flow through each filter. Found necessary to wash one filter per day; each filter washed on same day of week, except on Sundays. Anals. show iron completely removed from raw water. Sludge used by local gas works for removing sulfuretted hydrogen. Reservoir square in plan, 18′ deep, with reinforced concrete roof slab. Pumping station staff housed nearby in 4 semi-detached houses, each comprising parlor, living room, hall and scullery on ground floor and 3 bedrooms and bath upstairs. Total capital cost of works was £92,326 including: site, £553; trial borings, £2915; well, adit and boring, £35,800; pump house, £12,356; pumping plant, £9507; ozone plant, £1635; deferrization plant, £4635; reservoir, £9873; 15″ main (length 4644 yd.), £11,993; staff houses, £2668; and access road, compensation, etc., £391. Cost of power per 1000 gal. (Imp.) water pumped was 0.844*d.* for well pumps and 1.350*d.* for borehold pump. Station run by pump man and water treatment attendant earning £4 16*s.* 2*d.* and £4 8*s.* 8*d.* per week, resp. Avg. cost of wages and electricity per 1000 gal. (Imp.) delivered into supply was 1.55*d.* *Discussion:* Surveyor (Br.) **103:** 23 (Jan. 14, '44). *Borings in two formations at same site.* ANON. Two such cases had come to the author's attention—one at Luton, near Chatham, and the other at Rainham, Kent. At latter place found that greensand water bleeding up around outside of lining tubes at about 20,000 gal. (Imp.) per hr. and flow remained more or less const. ever since. Author could not agree that reinforced concrete lining much more expensive for well lining that brick in cement steining. In reply to Claud Pain, author could advance no reason for low hardness for chalk water at Boxley of 14.6° Clark, but figure compared with 15.8° and 14.4° avg. hardness for Maidstone Co.'s chalk springs at Boarley and Cossington nearby. Author glad to have approval of Walters of assessment of avg. percolation for chalk of lower greensand, and while he agreed that figure of 1 : 50 for slope of ground water not necessarily accurate, yet for purposes of assessment, certain values had to be assumed and those values should be conservative.—*H. E. Babbitt.*

Ozone Water Treatment at a Scarborough Swimming Pool. H. V. OVERFIELD. Wtr. & Wtr. Eng. (Br.) **46:** 427 (Oct. '43). Peasholm Gap open-air swimming pool constructed in '38. Pool, when filled with sea water, contains 420,000 gal. (Imp.) and has surface area of 17,000 sq.ft. Treatment comprises: (1) settling tank, 20,000 gal. (Imp.); (2) pressure filters with provision for dosing coagulant and alk.; (3) heaters to raise temp. 5° or 6° F. above air—in peacetime temp. of 69° F. maintd.; (4) sterilization by ozonized air. 5-years' operation experience justified adoption of ozone treatment. Circulation of water 73,000 gal. (Imp.) per hr. which makes turnover period 6 hr. When necessary to correct for acidity, alk., usually soda, applied so that pH kept between 7.2 and 7.6. After gas heaters filtered, water conducted to sterilizing tower. Above top of tower 12″ inlet pipe tapered to throat and drop in pressure takes place, which serves to draw air through dessicator and ozonizers. Pressure about 10.7 in vacuum water gage. Mixture of water and ozonized air carried downwards in reinforced concrete contact tower 16′ deep, with water capac. of 1195 cu.ft. Ozonized air remains in contact with water for approx. 6 min. until water overflows weir where most of air escapes to atmosphere. Air dried in silica gel dessicator reactivated at night. 2 ozone units. Blue color of silent elec. discharge becomes visible at 2500 v. Plant arranged to work up to 4250 v. In testing ozonized air, gas conducted into neutral soln. of KI. Ozone liberates I_2 as follows: $2KI + O_3 + H_2O = 2KOH + I_2 + O_2$. Titration is with $Na_2S_2O_3$ using starch as indicator. Error due to formation of iodate and periodate not large. Ozone perishes rubber tubing quickly and acts on copper. Corks for making joints also lead to leakage. Vol. of air flowing through ozonizers measured through orifice and checked with Pitot tube. When recirculating pump delivering 73,000 gal. (Imp.) per hr., air flow 5600 cu.ft. [Graph shows variation of approx. 0.6 g. ozone per 1000 gal. (Imp.) of water at 1000 v. to 3.6 g. at 7500 v., and 1.9 at 4000 v.] Routine tests made by plant attendant on water from contact tower. If good blue color obtained when crystal KI and few drops of starch soln. added, water sterile. Ozone production falls if moisture content of air

increases. Dose of 150 g. of ozone per hr. produced at 3700 v. and found to be sufficient for normal times with several hundred bathers. On warm days with heavy bathing loads 270 g. per hr. at 4250 v. necessary. *Discussion. Ibid.* **46**: 477 (Nov. '43). M. T. B. WHITSON: In '35, Ashton-under-Lyne, Stalybridge and Dunkinfield Water Works Com. had considered treatment of reservoir water heavily infested with algae and decided upon having ozone plant. Overfield treating swimming pool water effectively with elec. consumption of 60 whr. per 1000 gal. (Imp.) of water. Not expensive. Obstacle to our use was cost, compared with such sterilizers as chlorine. Second consideration which caused prejudice was matter of residual. With chlorine there was residual; with ozone none. That fact held up as disadvantage with argument that with residual ozone one would have safeguard against casual contamn. Third disadvantage lay in tech. nature of process concerned with production of ozone. Advantages of ozone summed up as: (1) perfect sterilizing agent; (2) rendered water inviting both in looks and taste; and (3) did not give rise to any odor. Following particulars of plants at Ashton and Scarborough:

	Scarborough	*Ashton*
Air flow (cu.ft./hr.)	5600	4900
Cycles (a-c.)	570	500
Voltage	300 to 4250	10,000 to 20,000

29 whr. required for production of 1 g. of ozone at Scarborough at 3700 v. and at Ashton at 10,000 v. E. V. SUCKLING: Established merits of ozonization included removal of color, odor and taste, together with destruction of bacteria. Not generally applicable and every case must be individually considered with great care. Rawson emphasized these limitations and drew attention to interference which might arise from manganese and iron in water under treatment. Limits to turbidity, discoloration and contamn. permissible before treatment with ozone. Dose of ozone administered varied between 0.45 and 0.8 ppm. in Scarborough swimming pool. —*H. E. Babbitt.*

CORROSION AND CORROSION CONTROL

Protective Paints for Steelwork in Tropical Climates. HARRY EDWARD WHITEHOUSE. J. Inst. Civ. Engrs. (Br.) **21**: 4: 199 (Feb. '44). Paper deals primarily with experiences gained during studies made to discover suitable paint for Lower Zambesi bridge in Portuguese East Africa. All steelwork, after being cleaned by wire brushing of rust, dirt, etc., and as much of mill scale as possible, given shop coat of proprietary paint at contractors' works. After erection at site, all rust and loose paint removed and 2 further coats of same paint applied. Std. of cleaning that usually accepted in work of this type. After site painting applied for some 4 or 5 mo., dull black powd. appeared in patches over surface. Areas affected became larger and in certain situations covered whole surface. After another 4 or 5 mo., rust stains showed through paint, and film appeared completely broken down. Microscopical examn. showed presence, per gram of powd., of 10 million spores of mycelium and 500,000 bacteria of type usually assocd. with soil and decaying vegetable matter. Both mycelium and bacteria successfully cultured in lab. and found that, under appropriate conditions of temp. and humidity, most paints of normal formulation similarly attacked. (Confirmed by later experience at site.) Appeared that oil in paint first attacked by fungus component of organisms, leaving surface in suitable condition for bact. development. After attack, permeability of film to moisture increased and rusting of metal below could begin. Rusting lifted what remained of paint film and accelerated further oxidation. Remaining paint film retained moisture in contact with metal; corrosion more intense on painted steel, paint on which had broken down, than on cleaned steel not painted. **Conditions at Site.** Atmospheric conditions at site of bridge do not favor rapid corrosion and, except at points where wind-blown dust and water tend to lie, unprotected steel corrodes only relatively slowly. Provided regular inspection made and all points where incipient corrosion noticed immediately patch painted with some, even if short-lived, protective coating, no danger of serious deterioration of structure. Considered advisable, therefore, to wait until coating with reasonable resistance to local organisms discovered, rather than paint bridge with something of only ephemeral

value, which would have to be renewed very frequently. Services of inspector retained to do necessary patch painting in order to insure that no deterioration occurred, and to supervize application of various trial paints sent to site from time to time. Owing to these precautions, although parts of bridge not completely painted for 8 yr. after erection, structure suffered in no way. Must not be inferred from this that steelwork need not be painted in such climates. Annual cost of inspection and patch painting higher than annual maint. cost of normal paint under normal conditions, although not so high as replacement cost of paint which would have to be renewed very frequently owing to fungoid attack. Further observation of fungoid and bact. attack on paint revealed following facts: (1) Intensity of attack varied in different parts of structure. Parts of bridge span continually exposed to bright sunlight and rain not so prone to attack as other parts few feet away more or less shaded from direct sunlight. Clear, therefore, that for optimum development of organisms, certain deg. of humidity necessary and bright sunshine slowed down attack, probably because temps. attained by steelwork exposed to continual sunlight lethal to organisms. Steel exposed to sunlight often attained temps. ranging up to 140° F. (2) After much longer lapse of time, shop coats of paint applied in England also attacked and broken down in similar way. (3) Once phenomenon noticed, found it was not peculiar to Zambesi Valley, but occurred in greater or less intensity over whole of lower lying areas of Portuguese East Africa and Nyasaland. Similar conditions encountered in other parts of world, such as Malaya and certain areas in India. After new products provided applied for some months, found that, although new paint more resistant to attack than original paint, modifications made had other less favorable results. Most serious was that, although film apparently dried more or less normally, yet for several weeks after application, during periods of high humidity with heavy morning mists, it softened and could be rubbed off with fingers, leaving steel below apparently wet. After relatively short time, rust began to form below film. Therefore, it appeared that modified paint, although more resistant to fungoid and bact. attack, gave little more protection to metal than did original paint. **Protective Coatings for Steelwork.** Much published about protective coatings for steelwork. Whole question of protective coatings for steelwork falls under following headings: (1) prepn. of surface prior to painting; (2) priming coats; and (3) subsequent coat or coats, with special reference to resistance to local conditions. (1) *Prepn. of Steelwork Prior to Painting.* Possible treatments as follows: (a) Removal of all loose rust and as much mill scale as can be removed by wire brushing, followed by priming coat at mfr.'s works. Handling during transport and erection causes breaks in shop coat and rupture of mill scale. Corrosion, therefore, often started before specified finishing coats applied, and in short time failure of protective coating inevitable. (b) Steelwork shipped without any prelim. treatment at works in hope that, during transport and erection, bulk of mill scale will have been sufficiently loosened to enable normal scraping and wire brushing to remove it before paint applied. This treatment usually condemned as little better than (a), but local experience shows it to be very much superior. Bridge span shipped to Nyasaland in '36 with no works treatment. Arrived at site too late in '36 for erection before rainy season and material stacked in open until May '37. Care taken that all steelwork supported clear of ground, vegetation kept clear and no rain water allowed to lie for any considerable time in any part of structure. Span then erected, thoroughly wire brushed and painted with normal 3-coat treatment. Possible to remove almost all mill scale and little, if any, serious rusting occurred. 5 yr. later, paint still in good condition. Under tropical African conditions far better to export steelwork untreated than to export it with shop coat of paint put on over mill scale. More or less same procedure recommended in British Std. Spec. No. 153 ('33). (c) Shipment of steelwork, either with or without shop coat, and subsequent removal of all mill scale and rust by sandblasting and chipping, followed by painting. Method eventually adopted on Zambesi bridge. Has several disadvantages, although final result may be satisfactory. Cleaning carried out under conditions of greater difficulty than at mfr.'s works, while suitable sand may not be easily available and can rarely be recovered and re-used. Staging more complicated and, as sandblasted steelwork has to be painted within few hours, each day's work has to be arranged at distance from that done on previous day in order to prevent dust from sandblasting

causing damage to still wet paint put on recently cleaned work. (d) Removal of all rust and mill scale before shipment, by sand-blasting, shotblasting, acid pickling, or other means, followed by rust-inhibitive priming coat at mfrs.' works. Best treatment of all. Avoids disadvantage of treatment (a), namely, difficulty of complete de-scaling below priming coat which, if left, may not become detached in places for several years, with danger that rusting below scale may continue undetected sufficient time for considerable corrosion to occur before being checked. Also avoids severe pitting so often accompanying broken scale films due to difference of potential between areas covered with scale and scale-free areas in presence of moisture. Possibility of deterioration between fabrication and final painting with treatment (b) also avoided. Treatment not widely advocated when specifications for Zambesi bridge drawn up and works cost of such treatment not known to author. Seems probable that complete de-scaling by sand- or shotblasting or by acid pickling, preferably in rust-inhibitive bath such as phosphoric acid, followed by priming coat put on immediately, will, in spite of increased prelim. cost, prove cheaper in long run. Cleaning costs on Zambesi bridge with native labor avgd. 8s. 6d. per ton after long period of weathering. Cost with more expensive labor for complete de-scaling of newly-fabricated steel would be much higher, possibly from 10s. to 20s. or more per ton. After treatment (d), all required after erection would be to make good any damage done to works coat during shipment and erection, followed by application of one or more coats suitable for local conditions prevalent where work finally erected. (2) *Priming Coats.* Main function of priming coat to protect surface of metal from corrosion either mechanically, chemically, or both. Paint coats applied directly to steel classified under 3 main types: (a) those which contain some constituent definitely inhibitive to corrosion; (b) those whose protection is entirely physical; and (c) those which tend to encourage corrosion. (a) Red lead probably best inhibitor of corrosion. Although local experience lacking, seems fairly well established that one of other types of rust-inhibitive primers contg. metallic chromates, while superior to red lead under some atm. conditions, such as near sea coast, inferior in indus. atmospheres where acid conditions present. Priming coat of red lead alone, however, more liable to damage and deterioration during transit and storage than some other primers and therefore not ideal for steelwork de-scaled at works and shipped to site with only priming coat. For this purpose priming coat more resistant to damage preferred. If final de-scaling and cleaning of steelwork carried out after erection, priming coat of red lead probably better than any other, although one of composite primers of red lead described below may have advantages. 8 primers of red lead supplied by different mfrs. tested on bridge. Of these 4 straight red lead paints, generally in linseed oil medium. Remaining 4 also contained one or more of following constituents: powd. zinc, flake aluminum, zinc oxide, iron oxide, barium sulfate or silica graphite. Composite primers generally easier to apply and had better covering power than pure red lead, which, with native labor under tropical conditions not easy paint to handle. Composite red lead primers generally mixed with vehicles of linseed oil, often polymerized or otherwise treated, but in some cases tung oil and synthetic resins also incorporated. Red lead in primers itself sufficiently resistant to fungoid and bact. attack to require no added fungicide, especially as primers exposed to attack for only few days before succeeding coats applied. Provided succeeding coats resistant to attack, incorporation of fungicide in priming coat not of great importance and in some respects may be inadvisable to incorporate fungicide in primer, since, by chem. reaction with pigment or with passive coat on steel, may break down any rust-inhibitive property of primer or any passivity produced by it, thereby encouraging corrosion. Apart from ease or otherwise of application, all red lead primers, whether pure or composite, found to give good protection to steel so long as subsequent coats protected primer. Once exposed, red lead has short life, especially if exposed to intense sunlight. Paint film soon becomes very brittle and powdery, and red lead apparently converted into lead carbonate. Some composite primers resisted this action considerably longer than pure red leads, especially those contg. flake aluminum. (b) Next class of priming paints tested those contg. pigments of iron oxide—in many cases natural iron ores contg. other constitutents as well. Primers contg. iron oxide from 8 different mfrs. tested. Of these, 5 natural iron ores contg. other constituents such as silica, bauxite, etc.; some contained some added constituent such as barium sulfate,

graphite, etc. Peculiar phenomenon observed with several, but not all, iron oxide primers. Under favorable conditions of humidity and shading from direct sunlight, these primers, after having been applied for some months on properly cleaned steel, formed on surface of metal very thin surface coating resembling mill scale. Coating very firmly adherent and afforded extremely good protection to metal. Whole of paint film could be scraped off, leaving "passive scale" on surface which, if unbroken, showed no sign of deterioration after many months of exposure. Scale not found below similar paint exposed to direct sunlight for greater part of day and its formation more noticeable on steelwork over water than on similar steelwork over dry land. Where formed, appeared to provide best protection of any of priming coats tested, although in situations where it did not form, primers with red lead base appeared to give better protection. Iron oxide primers generally prepd. with vehicle of linseed oil, in some cases polymerized or chlorinated. Other primers tested consisted of 3 types of metallic lead paints generally in complicated tung oil medium and one paint with chlorinated rubber base. These do not appear to possess any outstanding merit, although, when covered by suitable finishing coats, results satisfactory. "Protective scale," produced by certain iron oxide primers under favorable conditions, merits further study and, if formation could be guaranteed, these paints would appear to be superior to any others. Apart from portions of structure where scale formed, best priming coat seemed to be red lead, either alone or mixed with other constituents. Most important point, however, is that priming coats must be adequately protected by succeeding coats, and upon this protection life of entire treatment depends. (c) Constituents which tend to encourage corrosion generally well known and include some types of graphite. These constituents not usually included in paints for steelwork, but sometimes form valuable constituents of paints for other purposes. Their use on steelwork, particularly if used in direct contact with metal, to be avoided. (3) *Finishing Coat or Coats.* Function of these coats to protect priming coat from deterioration by atm. or other agencies and to prevent access of moisture to underlying coats or to metal. Conditions which paint films have to withstand lie between extremes of: (a) situations exposed for the greater part of day to direct sunlight and where rain immediately runs off or soon evaporates; (b) situations shaded from direct sunlight and on which dew forming during night liable to remain for considerable periods, or where rain can collect in small quants. and remain for days during rainy weather. Between these extremes almost every variation found on large structure. When exposed to long periods of intense sunlight, paint films behaved in slightly different ways. Original gloss of film first disappeared, paint becoming slightly lighter in color. Time taken for this change varied with different paints, those with varnish medium contg. synthetic resins generally retaining gloss longer than those with purely oil medium. Pigment of some paints then began to "chalk," and fine powd. of color of paint could be brushed off. Rain also washed loose pigment from surface and exposed further layer to attack. With some paints, owing to continuous heavy "chalking," finishing and undercoats almost entirely destroyed, exposing priming coat. Where heavy chalking occurred, cracking of film seldom noticed, also significant that paint which chalked heavily only slightly attacked by fungus and bacteria. Paints most affected by chalking generally those of light color, particularly if zinc oxide or titanium oxide formed part of pigment. With some paints, after loss of gloss, film became dry and very brittle, and eventually cracked, permitting entrance of moisture to underlying coats and eventually to metal below. This cracking often accompanied by little chalking. Cracking ranged from minute hair cracks very close together and hardly discernible with naked eye to much wider cracks at greater distance apart. In some cases cracks followed irregular pattern similar to skin of crocodile, while in other cases parallel, following line of brush marks. Type of cracking seemed to depend upon deg. of elasticity retained by underlying coats. One or two samples of clear synthetic resin varnish put on over other paints as finishing coat. This varnish retained its gloss for considerable period, but eventually chalking of pigment of underlying coat lifted varnish film which could be peeled off in large flakes. Aluminum paints stood up best in situations exposed to bright sunlight. Of these, samples having vehicles compounded of processed tung and linseed oils with ester gums or other synthetic resins superior to those with less complex media. Seemed to be little to choose between best aluminum

paints shipped ready-mixed and those shipped with powd. and medium separate. Found that 2 coats of aluminum paint put on over one coat of suitable primer, giving thin but good cover, withstood sunlight better than one coat of same paint put on over 2 coats of normal oil paint. Thicker cushion of oil paint between aluminum paint and metal appeared to be prejudicial when exposed to intense sunlight. Found that aluminum finishing coats adhered much better to coats below if primer and undercoat also contained leaf aluminum as part of pigment. Particularly true in damp situations. Reflective nature of aluminum pigment appears to protect medium from effects of sunlight better than do more granular pigments. In intermediate situations, wholly or considerably protected from direct sunlight, and where water does not tend to lie, main cause of breakdown of paint on Zambesi bridge fungoid and bact. attack. Paint prepd. with effective fungicides stood up as well under these conditions as normally formulated paints do under similar conditions in temperate climates. Exact nature of fungicides used by various mfrs. not revealed, but fungicides must obey following conditions: (1) Must not be volatile or soluble in water; otherwise they would seen be evapd. or leached out from surface layer, rendering it liable to attack. (2) Must be chemically inert towards both vehicle and paint pigments with which they are incorporated and be unaffected by atm. agencies; otherwise effect as fungicides might be destroyed. (3) For better dispersion throughout paint desirable that part of fungicide used should be soluble in medium of paint. (4) Inclusion of fungicides must not cause deterioration during reasonable storage before use, or affect ease of application, rate of drying and hardening or permeability of film. (5) Fungicides should not, owing to poisonous nature, make paint dangerous to handle. Particularly important with native labor. One type of fungicide used was some org. compd., such as naphthanate or phenyl-oleate of copper or mercury, soluble in some constituent of medium. In some paints compds. of copper, in addn., incorporated with pigment. Other types, including inorg. mercurial compds. or small quants. of arsenic oxide or copper aceto-arsenate, gave suitable protection. Boric acid also suggested as suitable fungicide. Several organisms known to be present, and one fungicide may be toxic to one organism while encouraging growth of another. May explain difference in form of attack on some of earlier types of paint tested, found not completely immune. Media compounded of tung oil and various synthetic resins much less palatable to attacking organisms than those of linseed oil. Some types of treated linseed oil appeared to be more resistant than untreated oil. Certain pigments seem to have property of restraining fungoid and bact. attack. Among these are red lead, some compds. of zinc, and metallic aluminum. Observed also that pigments which show excessive chalking in bright sunlight not very actively attacked in shaded situations. On some paints first symptom of attack was formation of loose black powd. on surface, easily dusted off, but which rapidly reappeared. Appeared first over small areas but spread gradually until powd. covered most of surface. Moisture then penetrated film and rusting started below, first as stain which could be seen. Later film lifted and easily rubbed off, exposing rust on metal below. On other paints small black specks first appeared not easily rubbed off, but when removed left slight pits in surface of paint. More and more specks appeared and depth of pits slowly increased. Cycle of events on some paints with fungicide-content not quite resistant to normal attack or only resistant to some organisms. In some cases it continued until complete penetration occurred, while in others apparently ceased after a time and no further action observed. At opposite extreme are situations where rain water tends to lie in small quants. which cannot be drained off, or where const. drip from superstructure during foggy weather or heavy dew keeps paint wet, often for several hours on many days of year. Under such conditions aluminum paints perhaps *least* successful of all. Aluminum paints more resistant if put on over 2 coats of oil paint, undercoat preferably compounded in medium contg. processed tung oil and synthetic resins. Some could, while still damp, be stripped off in large flakes, 1 sq.in. or more in area, while others showed signs of rust staining below and eventually lifted. In such situations max. watertightness of undercoat and finishing coat evidently necessary. 3-coat treatment almost essential to guard against inadvertent flaws in various coats. Such flaws due to various causes, including: (1) Carelessness on part of painter; best guarded against by having all coats sufficiently different in color so that spots

missed can be seen at once. In treatments where 2 coats of same paint to be employed always arranged to have half quant. ordered tinted slightly different color. This policy adopted even when 2 coats of aluminum paint used, part used as undercoat tinted green or pink. Small pin-holes in coats, however, almost impossible to avoid. (2) In windy weather almost impossible to avoid settlement of sand and other foreign bodies on wet paint. Although all paint brushed over with soft brush before applying next coat, sand thus embedded tended to produce minute holes in film. (3) Small pits in metal, sharp edges of plates and rivet-heads liable to cause irregularities in thickness of paint film, especially with native labor. In situations where water tends to lie, best type of treatment seemed to be primer of rust-inhibitive type with medium which did not dry out rapidly but remained elastic for as long as possible, followed by undercoat with anti-fungus and anti-bact. properties in medium with properties lying between those of primer and finishing coat. Finishing coat had to offer max. resistance to penetration of moisture, fungoid and bact. attack and deterioration by sun's rays. Media most successful generally compounded with tung oil, processed linseed oil and various synthetic resins of glyptal, coumarine or other types and necessary proportions of white spirit, driers, etc. In other words, a medium of varnish type compounded for max. watertightness combined with retention of elasticity when exposed to tropical sun required. Bituminous paints and tar resisted action of tropical sunlight for only very short time. Film shrank and formed pattern like crocodile skin and at same time became very brittle. Before new coat could be applied satisfactorily, all old coat had to be scraped off. Therefore use of these paints not economical, unless in situations not exposed to direct sunlight. **Large-Scale Painting Operations.** Evident, therefore, that no one type of paint gave max. protection under all conditions and following—perhaps unorthodox and unaesthetic—policy adopted for large-scale painting operations begun late in '40 and completed during '42. (a) *De-scaling and cleaning:* Much easier to remove all mill scale from rolled sections, e.g., angles and beams, than from plates. In fact, very little mill scale present on sections when shipped, but on plates used in bldg. up webs of plate girders and upper and lower booms of large spans, mill scale, having been painted over at mfr.'s works, very difficult to remove. 5 yr. or more after erection almost impossible to remove all mill scale by normal methods of wire brushing and scraping. Expts. made with sandblasting completely successful, but outbreak of war rendered it impossible to obtain necessary compressors and other plant for sandblasting whole bridge. Sufficient plant available for sandblasting part of structure. Noticed that some parts of bridge much more liable to corrosion than others, and that on Nyasaland Railways, on cleaning bridgework for painting in situations less liable to corrosion, no mill scale left and some corrosion evident. In parts of Zambesi bridge liable to corrosion, some signs of lifting of mill scale evident, but shop coat of paint prevented any considerable de-scaling by means of scraping and brushing alone. As compromise enforced by present conditions, those parts of bridge least liable to corrosion wire brushed and mill scale removed by scraping. Such parts comprised verticals and diagonals, upper wind bracing and parts of upper chord members. Parts where corrosion more dangerous and signs of lifting of mill scale evident cleaned by sandblasting. Steelwork cleaned by sandblasting given priming coat on same day, and, until this priming coat sufficiently dry, subsequent day's sandblasting done at such distance that paint still damp clear of dust and flying sand from nozzles. Factor somewhat delayed work and increased quant. of scaffolding used. As rough est. about 30% of steelwork cleaned by sandblast. At first sand all screened to remove fine particles as well as those too large to pass through nozzles. Later, only large particles taken out. Main essential to have sand perfectly dry; otherwise clogged nozzles. As ample sand available in river bed, no attempt made to recover and re-use it. When operators became expert, cleaning rate of about 1½–2 sq.ft. per min. could be maint. All surfaces from which mill scale had started to lift thoroughly cleaned by sandblast, but rolled sections with little or no mill scale and areas where mill scale showed no signs of lifting after 5 yr., cleaned by wire brushing and scraping. Desirable to sandblast all surfaces where mill scale existed but not possible and expected that little scale left will cause deterioration only at rate equal to or lower than that which will occur in more exposed but properly cleaned surfaces. About 30% of steelwork cleaned by sand-

blast; further 30%, mainly in verticals and diagonals, where little or no mill scale, efficiently cleaned by scraping and brushing. Remainder cleaned as perfectly as possible by scraping and brushing and included only those areas where no corrosion occurred, although no paint other than shop coat applied. (b) *Painting.* All parts of structure constantly exposed to direct intense sunlight painted with aluminium paint. On part of bridge normal red lead primer used and on remainder composite primer with red lead, metallic zinc dust and aluminum. Covered with 2 coats of aluminum paint mixed in medium of processed oils and gums with addn. of fungicides. On remainder of steel spans various oil paints used, some brown in color and others green. Brown paints used on south approach viaduct, secondary spans and first 12 main spans and green paints on remaining 21 main spans and north approach spans. Treatments adopted those which stood up best to tests made and each mfr.'s treatment in general used alone, i.e., paint from one mfr. not applied over paint from another. With one exception, all treatments comprised 3 coats. 2-coat treatment used on those parts of several spans painted with it which were least liable to corrosion, red lead primer being used below where better protection appeared to be needed. 2 straight red lead, 1 composite red lead, 1 metallic lead and 3 iron oxide primers used. In each case, finishing coat comprised complex medium of processed linseed or tung oil, or both, with resin. Complete record of paint used on each part of every span kept and hoped that ultimately one treatment may be selected from many which, during necessarily restricted testing period, appeared to have equal merit. Apart from 2-coat treatment referred to above, little difference in cost found between various schemes tried, although in some cases expensive primer covered by 2 cheaper coats and in others comparatively inexpensive primer used below undercoating and finishing coats of higher price. Red lead primers generally more expensive than iron oxide primers, but mfrs. apparently felt justified in recommending less costly finishing coats over them. Insides of end boxes of large spans and phoenix columns and bracings of south approach viaduct, coated with mixture of 10-gal. coal tar, 40 lb. portland cement and 2½ gal. paraffin, applied hot. Viaduct columns originally treated with bitumastic composition fairly successful but had become very brittle. Parts of columns liable to be surrounded by almost stagnant water for considerable periods during high floods and, although several exptl. treatments applied, none entirely successful. Serious floods occur with comparative rarity, most recent being in '18, '26, '27 and '39, and necessary to paint parts affected with some cheap composition such as that described above after each flood. Found that several points required special attention during work of painting. (1) With most paints, and especially those contg. red lead, pigment tends to settle at bottom of drums and in time becomes very hard. To avoid this, all drums of paint in stock turned over end for end once each week. (2) When opened for use, contents thoroughly mixed before being turned out. In some cases this occupied almost full day before all sediment thoroughly incorporated. Contents of several drums then turned out into a 40-gal. container from which painters took their supplies. Paint in this container stirred continually during working hours. (3) Care taken that each coat thoroughly dry and hard before next coat applied. With some paints this took as long as 10 days. (4) Painting never begun in morning until steel thoroughly dry. Particularly insisted upon in case of priming coat, to insure that no moisture sealed in pores of steel. (5) Many paints, as received, too thick to be brushed out satisfactorily, especially when metal hot. Mfrs. consulted and some allowed small quant. of white spirit (turpentine) added. Others supplied special thinners contg. some oil. Generally more satisfactory than white spirit but, in order to avoid upsetting fungicide balance of paint, untreated oil not used. Least possible quant. of thinners, consistent with obtaining reasonable working consistency, added. *Conclusions.* Confidently expected that painting will remain in good condition at least for 5 or 6 yr., although few places, such as insides of lower booms, may require some touching up before then. Following recommendations made for works treatment and site painting of structural steelwork to be erected in low-lying tropical areas. All steelwork should be thoroughly cleaned of all rust and mill scale and painted with suitable primer at mfr.'s works. As considerable period will then elapse between priming coat and final coats, such primer should have following 2 essentials: should be able as far as possible to resist abrasion and normal damage due to handling and erection and

should embody a fungicide sufficiently powerful to resist attack after drying. Should development of protective scale under some iron oxide primers be sufficiently understood that its production can be guaranteed, steelwork so "scaled" would be in ideal condition for erection in any climate. Does not appear logical to embed pigment with rust-inhibitive properties in medium which, when hard, so completely seals it that its properties can never be exercised until the medium begins to break down. Production of passive surface coating by use of inhibitive washes, such as phosphoric acid-sodium dichromate soln., or by other means before painting, appears to be more promising. Subsequent coats should be adapted to conditions which they will be called upon to resist. Means of resisting such conditions in Zambesi Valley described. Apart from coastal and indus. areas, probably as exacting as any to be found. Usually possible to test normal paint treatments during early stages of new works and if found that these break down, prelim. studies of such abnormal conditions can be made. Thorough cleaning and efficient priming will, in general, stand up satisfactorily until a suitable final treatment can be discovered. Use of different paint treatments on different parts of important structure appears to be necessary; thought that very considerable economies can often be secured by this means. —*Ed.*

The Corrosion of Mains in Clay Soils. H. J. Bunker. Surveyor (Br.) **102:** 443, 459 (Oct. 29, Nov. 5, '43). Survey of cases of rapid corrosion of buried pipes indicate that soil in which they are buried usually clay and, if not actual water-logging, absence of aeration. In case of c-i. mains, this type of corrosion characterized by graphitization. Pipe retains outward form, light to handle, and may have become so soft can be cut away with knife or scratched by finger nail. Softness due to removal of iron leaving behind matrix of graphite. Graphitization may, from time to time, originate from interior surface of pipes. When burst pipe excavated often found that soil in immediate vicinity black and, on exposure to air, discoloration disappears in short time. In some cases possible to detect unpleasant odor, as sulfuretted hydrogen. Reaction of soil neutral or alk. Any appreciable acidity would prevent anaerobic corrosion. Presence of sulfates characteristic of soils in which anaerobic corrosion occurs. Another characteristic feature of this type of corrosion is ready evolution of hydrogen sulfide when some of corrosion products treated with hydrochloric acid. This type of corrosion occurs frequently in dists. where existence of stray elec. currents difficult to demonstrate. Chem. explanations based on participation of sulfate radical postulated. Not only no pos. evidence of correctness of this theory but fact stands out that soil does not become acid. Sulfate-reducing bacteria provide mechanism of anaerobic soil corrosion. These micro-organisms widespread in nature and flourish under anaerobic conditions; very resistant to adverse conditions and survive in air for long periods (immediately resume activities when local conditions become favorable); withstand wide range of pH from 4 to 11 and wide range of temp.; and various strains tolerate appreciable concns. of salts in soln. Org. matter assimilable by organisms in variety of forms. Underlying principle of metallic corrosion is that ions of metal pass into soln. at anodic points with simultaneous discharge of hydrogen at cathodic points. In neutral environment, oxygen present combines with hydrogen and prevents cathodic polarization. Follows that where oxygen absent corrosion should come to standstill. In clay soils anaerobic conditions with corrosion proceeding vigorously. Hence, some hydrogen acceptor other than oxygen must be present. Sulfate-reducing bacteria play essential role. By reducing sulfates to sulfides, bacteria render sulfate available as hydrogen acceptor. At same time, H_2S, resulting from reduction of sulfates, combines with iron ions with consequent deposition of iron sulfide. von Wolzogen Kuhr first to draw attention to relationship between sulfate-reducing bacteria and anaerobic corrosion in clay soils. Chem. Research Lab. at Teddington had already travelled long way on same road. Kuhr's published findings of qual. nature. At Teddington these fortified by quant. data. Initial lab. expts. at Teddington gave encouraging results. Any sulfate-bearing clay is suspect. Lack of depth enchances danger on acct. of greater likelihood of presence of org. matter. Where reaction of soil acid, risk less. Measurement of oxidation-reduction potential of soil will afford indication of likelihood of microbiol. corrosion. Methods of prevention may be classified as those which prevent access of sulfate-reducing bacteria to surface of metal and those which arrest activity of

bacteria. Access of bacteria to metal same thing as access of moisture. Many prepns. for coating of pipes applied with varying degs. of success. Real trouble with coatings is making them perfect. Simplest method of dealing with problem is by killing bacteria but in most cases impractical. If main given surrounding of about 9" of sand or gravel, problem would probably be solved. Where short lengths of service pipe involved, should be no serious obstacle to this method. Other methods would be to alter reaction of soil or to use poisons. Use of steel contg. copper suggests itself. Tried at Teddington and found ineffective. Another line of attack is cathodic protection, by inducing elec. current to flow so that pipe no longer anodic. If engr. faced with corrosion already operating, little to offer in way of stopping trouble.—*H. E. Babbitt.*

Use and Misuse of the Salt-Spray Test as Applied to Electro-deposited Metallic Finishes. C. H. Sample. A.S.T.M. Bul. *No.* 123 ('43); Metal Ind. **63**: 26: 410 ('43). Lack of exptl. data correlating salt-spray and service behavior, and test often too widely used in specifications. For electro-neg. metals, thickness appears to be best measure of protective value. For electro-pos. metals, salt-spray test frequently useful in evalg. porosity, but not particularly suited for comparing different combinations of coatings and basic metals unless potential relations same. Further standardization of temp., air pressure, soln. composition and other operating variables urged.—*I.M.*

Present Position of the Iron and Steel Institute Corrosion Committee's Field Tests on Atmospheric Corrosion of Galvanized Materials (Unpainted Specimens). J. C. Hudson. Iron Steel Inst. Preprint (Aug. '43). Results of series of 5-yr. tests on atmospheric corrosion at 7 home and 7 overseas stations recorded and discussed. Most severe corrosion observed at Sheffield, and, in comparison, corrosion of ferrous metals in non-indus., tropical or sub-polar climates slight. In marine atmospheres and some other conditions, however, severe corrosion may occur if scaly rust allowed to form on surface. Wrought irons contg. much slag more resistant to atmospheric corrosion than mild steel, but those with low slag content and Aston-Byers iron more corrodible. Addn. of small amts. of copper improves corrosion-resistance of steel in open air, but not in railway tunnels; chromium, silicon, nickel and arsenic beneficial. Surface conditions of specimens have little influence on their resistance to corrosion. Hot galvanized steel specimens exposed to rural atmosphere in Wales for 11 yr. show little sign of deterioration; in half of specimens zinc coating contains 0.5% copper. If galvanized sheets replaced by black sheets, thickness should be increased by at least 0.020"; and for equal resistance to corrosion galvanized sheet 0.064" thick should be replaced by black plate 0.102" thick, and 0.018" galvanized sheet by 0.056" black plate. Loss of wt. after 1 and 5 yr. of small zinc specimens exposed as controls at each station recorded and results tabulated.—*I.M.*

The Effect of Aluminum on the Strength of the Coatings in Galvanizing. G. K. Lvov & T. S. Shchegol. Ural Metal. (U.S.S.R.) **9**: 3: 16 ('40); Chem. Zentr. (Ger.) **111**: II: 3700 ('40). [In Russian]. Formation of intermediate layers between iron and zinc in galvanizing discussed. Results of expts. in galvanizing with pure zinc, zinc + 0.5% tin, zinc + 0.1–1% aluminum, and zinc + 0.5% tin + 0.1% aluminum, given. Addn. of tin to zinc has undesirable effects of reducing tensile properties of zinc coating and causing greater consumption of zinc, thus increasing cost of process. Most suitable addn. of aluminum is 0.5%; greatly increases strength of zinc layer up to that of base material itself. Consumption of molten zinc reduced by it from 330 to 150 g./m.^{2}—*I.M.*

Water as a Source of Lead Poisoning. J. J. L. Harmand. Thesis. (Nancy) 368 pp. ('41); Presse méd. (Fr.) **51**: 3: 22 ('43). Corrosive action of water of certain French regions on lead plumbing discussed. Methods described to measure extent of corrosion. Water contg. 1 mg./l. lead not fit for human consumption. Lead poisoning favored by strong gastric acidity (this explains greater resistance of herbivorous animals), as well as by biliary acids. Poisoning becomes manifest as soon as sufficiently large concn. of lead in different organs, and as soon as localization of lead exceeds quant. excreted in urine. Prevention by treatment of water with Ca, Mg, marble filters, etc., suggested.—*C.A.*

Check the Use of Water

By D. E. Davis

WAR activities have brought new industrial and housing developments and increased water demands to many United States communities. It has not always been possible to expand water plant facilities quickly to meet these additional loads, and other solutions have had to be found.

As an example, Philadelphia and some of its suburbs were faced with such a situation. When representatives of the several communities met to discuss ways of meeting the crisis, they decided the best thing to do was to tell the public the facts and ask for water conservation.

A series of radio talks was prepared; a poster campaign was planned. The press cooperated, presenting the facts without glossing them over, and suggestions of ways in which water use could be curtailed were publicized. The response from the public was immediate and the new requirements were met with a reduction in previous pumpage rates.

However, any water works, whether faced with emergency needs or not, will find on careful examination, that the unaccounted for water might be made to yield some margin of extra supply and revenue. War or no war, it is good practice to use water rightly, particularly since lax peacetime water works operation in some instances developed unaccounted for water in excess of 50 per cent.

Metered registration for a given period can be equated against the pumpage; unmetered uses at the plant, at fires and for street and sewer cleaning, can be estimated. The remainder will represent leakage, under-registration of meters, or unauthorized use of water.

If the supply is stored in reservoirs, a pressure recording gage placed at the storage reservoir will record the flow during the morning hours when, normally, the least amount of water is being used. If the gage shows an unusually high use of water, it may indicate unsuspected leakage in the system. A leak survey may not be practicable, but the water works operator can have hydrants tested with an aquaphone to locate large leaks; he can look over valves and curb cocks; a leak finder should reveal the exact location of leaks. Certain areas can be valved off. A pitometer placed at the reservoir, or a meter placed on a by-pass at the reservoir, will show the reduction in use of water in a particular district, and the return to normal when valve is opened.

Each district can be checked separately. Smaller areas can be checked as noted above, or a pitometer can be set at the main feed to the district and

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smaller areas checked by appropriate valve closures. It is best to work at night when water consumption is low and when there is little traffic interference.

If leaks have been reduced somewhat, and the unaccounted for water is still high, the meters should be checked, particularly the large meters.

At one plant where large meters were tested by use of a pitometer, the results were so revealing that back charges were made to some industries, and a new policy was adopted of not permitting water to be taken continuously through detector meters on fire lines, even though all fire lines were metered. Compound meters were installed on all regular service lines, or a battery of small disc meters, and meters smaller than the service line were suggested.

One of the meter men in one water works plant has been assigned the duty of examining all bills at every reading to compare them with previous readings. If there is a reduction in any bill, an investigation is made and if the meter has stopped or slowed up it is brought in for testing.

One water works superintendent checks leakage by sending meter readers over the system at other than regular meter reading periods. The valve of the meter is closed and an aquaphone applied to the service line.

Another method of obtaining a rough check on leakage, and water used by large consumers, is to install a recording and indicating meter at the pumping station. Preferably, standpipes on reservoirs should be closed so that all delivery to the area tested would be from the station. The temporary stoppage of flow for as much as two minutes should be reflected immediately in a reduction in pumpage at the station.

To check large meters in small cities, the meter should be read for a few minutes to determine the rate of the recorded flow; then the supply should be shut off for a brief interval and the reduction in delivery noted at the pump station. This will show whether or not a more exact check would be justified.

War expansion has taxed existing facilities in some communities served by wells. The drilling of new wells is not always an adequate answer. Such a condition exists on a large river where a number of war plants have been built, many of them taking their supplies from the so-called underground stream in the gravel and sand bed beneath the river. The combined use has seriously depleted the supply and the ground water elevation has receded until some of the well screens are exposed.

The re-use of some of the water and construction of cooling towers are some of the more obvious solutions. Municipalities would probably be justified in refusing water for air conditioning systems during the emergency; the luxury of street showers in the summer could be stopped, and wasteful methods of street sprinkling might be corrected.

A distribution system should produce to full capacity to conserve labor and material. Closed or partly closed valves often introduce obstructions, that when removed may relieve critical supply situations without the need of installing new lines. One source of trouble is from valves which open in different directions, and which are closed by mistake. The best remedy for this is to change the threads of the valves so that they all open in the same direction. If this cannot be done, some means of identifying this condition

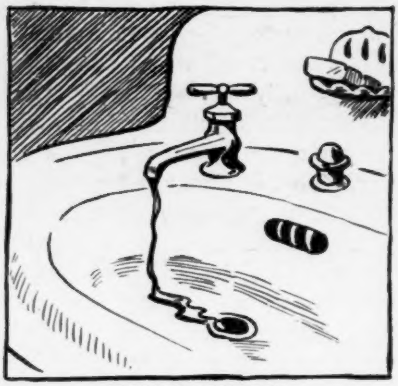
should be adopted—a lettered board in the valve box might be one way.

A wide-awake superintendent can learn much about his system by singling out certain areas for study. Where conditions are unsatisfactory, static pressure readings can be taken on hydrants along the principal artery in the area. Corresponding hydraulic elevations for that particular condition of flow can then be calculated. If one or more hydrants are later opened at the far end of the district, and the hydrant observations again taken, similar calculations for the second observed condition can be developed. The plotting of the corresponding hydraulic gradients will often furnish evidence of the conditions within the area which may afford suggestions for early correction of unsatisfactory flow conditions.

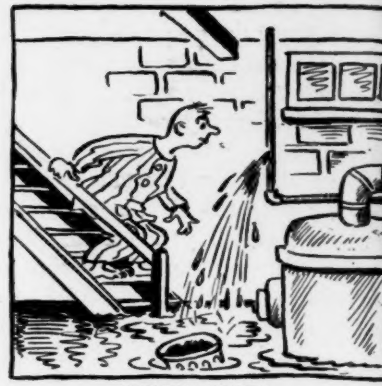
The subject of water conservation would hardly be adequately treated without some mention of the need of maintaining morale in the operating force. This is always a problem, and particularly so under present difficult operating conditions. A clean plant is a morale builder. Cleanliness and neatness at the pumping station and other plant building and grounds, should be stressed, since a clean plant is an efficient plant.

The thickness of the grease on operating equipment is almost always an index to the efficiency of the plant.

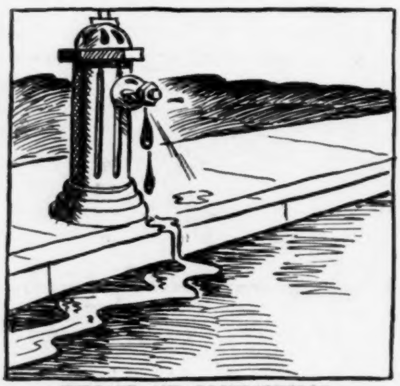
There is no priority on cleanliness.



DRIPPING FAUCETS



LEAKING PIPES



HYDRANT AND DISTRIBUTION
SYSTEM LEAKS

INDUSTRIAL WASTE

WRONG TYPE OF
SPRINKLING IRRIGATION

UNNECESSARY USE OF
WATER

These illustrations are from the book Water Conservation which can be ordered by writing to the A.W.W.A.